Semantic Web and Information Extraction

Author:
Ali Kiyan

Assessor:
Professor Apostolos Antonacopoulos

April, 2017

The UK Bird Watching Society, UBWS, wants to develop a Semantic Web about birds in different areas around the UK.
These areas are divided to 4 main categories and each area has some species

1. Built-up areas :

Sparrowhawks, Carrion crow, Swift, Blackbird

2. Countryside :

Barn owl, Bullfinch, Green woodpeckers, Blackcap

3. Coastal areas :

Kingfisher, Lapwing, Meadow pipit, Merlin

4. Nature reserves :

Turtle dove, Slavonian grebe, Linnet, Little egret

Each species has information that has been collected from 3 different datasource

- Text describing the bird's natural habitat
- Colour photographs
- Sound Recording

1-1 Acquiring the data

As mentioned, there are three different types of data source we can extract data in this project
First of all extracting information from all of these three resources can be done manually by human but it is time consuming and not efficient so we can deploy algorithms and techniques to improve this process.
The first part is extracting information from color images and there are 2 main algorithms called segmentation and classification. Segmentation has two approach for deciding which pixel belongs to a region. First approach is choosing pixel based on basic values like intensity and color and the second approach is by finding the boundary and then pixel within this boundary are assigned to a region.
In the first approach of image segmentation by region have some methods, namely Thresholding, Clustering and histogram-based algorithms.First method is simply grouping pixels by their intensity value. The second method can use different distance measures like location, texture or a weighted combination. In the third method, histograms of intensity/ colour values are computed for all the pixels and the valleys/troughs determine each region.
The second approach is using boundaries to identify the pixels that lie on the boundary of a region and there are two method called Thresholding and edge detection.

Thresholding is simply decide the boundary pixels when they lie between lower and upper threshold. The edge detection on the other hand, has two operator. Sobel and canny. They are designed to highlight any discontinuities around a pixel and consider the highest edge strengths as boundaries.In bird color photo with thresholding and clustering algorithms the bird in a picture can be identified. The main challenge is to find the the other entities like eye color and leg color and iris color which needs more precise measurement. For example more accurate histogram could be used to identify the colour of each part of the birds' body but the histogram should be drawn precisely. The second approach has better performance in this matter.

Second approach in image segmentation can be used for identifying the birds and it is not efficient for identifying body part colour of the birds.

The second approach is deriving properties for segments that helps identifying that segment as specific entities. These derived attributes can be low level attributes or the progressive combination of these attributes which is called high level attributes. In birds' case, statistic measures like means and skewness and standard deviation can be used for distribution of colour in a photo to identify the color of each body part or for better results they can be combined or non-linear classification techniques such as Artificial

Neutral Networks (ANN) to interpret a region can be used.

The last part is extracting information from text sources. These information of birds can be extracted from books, articles, webpages and many other text resources. The fist step is tokenisation and in this level the text document is splits into building blocks like words or sentences based upon the punctuation and spaces. For example block of paragraphs containing information about each attributes of a bird's voice.

The second step is annotating the tokenised bird's data first with provisional tag based on morphological rules and then with the help of contextual rules some tags may be corrected by examining the small portion of context. All of the annotating process is done by part of speech tagger which can provide additional output of stems sequence by using stemming algorithms.These algorithms try to reduce the words to their stems in the following ways :

- Lookup tables :

they are fast but this approach is not flexible since it cannot take new words.

- Production Rules :

It is a flexible semi-automatic approach but it may generate invalid combination of morphemes.

- Suffix stripping/substitution

This approach tries to remove a suffix or replaces it with proper different suffix.

If the tagger relies on automatic approaches it is called unsupervised algorithms and if the tagger is based on pre defined tag link the look tables, it is called supervised tagger.
After annotating the bird's data sense ambiguities techniques can be used like examining the neighbor tags and high co-occurrence words to resolve ambiguity issue of morphological analysis to some extent.

The third step is syntactic analysis of bird's text data according to certain grammar. There are two approaches in parsing the text. Deep parsing and shallow parsing. Deep parsing provide complete analysis of sentences using two basic division grammar, Constituency and dependency grammar. This parsing is not robust and is rather expensive for the purpose of developing a semantic web for birds. Shallow parsing on the other hand, analyse only the unambiguous part of the text and it is fast and robust and suits better for extracting birds information.
The last step is very common step in information extraction from text. In this step all the information form last steps are collected to form an entity and its relationships. In this step all the information about specific birds and their voice attributes can be formed. The way it is implemented may vary in different domains and the level of depth of analysis. For example, the following pattern can be used for extraction information about sparrow hawk voice.

BirdName @has PitchRelated DurationRelated Loudness related voice Connector @is PitchRelated

The main challenge in relation extraction is co-reference resolution. Anaphora Resolution can be used especially in case of pronominal resolution.
For example in the sentence "Swift has high-pitched voice. It has also regular voice and it is believed that it has normal durable voice " it and swift are co-references and two shallow and deep parsing can be deployed depending of domain. In birds text extraction shallow parsing is sufficient. The overall structure of most pronoun resolutions is first identify the relevant paragraphs and then use consistency check on probable candidate and assign a salience value and lastly pick the candidate with the highest value.
It is worth mentioning that in the collection process different attributes like length can be collect form different sources alternatively. (in some bird length is extracted from text and in some bird it extracted from photographs)

(Eurasian) Sparrowhawks	
Information extracted from text	
Natural habitat	Wood lands and gardens, towns and also rural areas except for part of Scottish Highlands, the Western Isles and shetland.
Nocturnal	No
Migration pattern	From colder regions of northern Europe and Asia migrate south for the winter, some to north Africa and India; members of the southern populations are resident or disperse.
Type	Bird of prey
Typical food	Finches,sparrows,buntings,thrushes,starlings
Interesting Fact	Males move further and more often than females of migrating birds ringed at Kaliningrad, Russia, the average distance moved before recovery was 1,328 km for males and 927 km for females.
Mass	110-342 g
Number of eggs laid	4-5
Lifespan	4 years
Wingspan	23-31 in
Information extracted from photographs	

Eye	Yellow or Orange
Size	Medium
Length	11-16 in
Male	
Colour	Slate-grey upperparts and finely red-barred underparts
Female	
Colour	Greyish-brown upperparts and brown barred underparts
Information extracted from Sound	
Loudness	Medium
Pitch	High-pitched sound
Duration	Long
Regularity	Regular pattern

Carrion crow	
Information extracted from text	
Natural habitat	Cities, upland moorlands, and from woodlands to seeshore
Nocturnal	No
Migration pattern	Mostly resident of western Europe
Type	Prey
Typical food	Scavengers by nature
Interesting Fact	Can be tamed
Mass	370-650 g
Number of eggs laid	3-4
Lifespan	19 years
Wingspan	37-42 in
Information extracted from photographs	
Eye	Black
Size	Medium
Length	18-19 in
Colour	Black and grey in the underpart

Information extracted from Sound	
Loudness	Loud
Pitch	Low-pitched sound
Duration	Long
Regularity	Regular pattern

Swift	
Information extracted from text	
Natural habitat	Rooftops
Nocturnal	No
Migration pattern	Migrate to Africa in winter some may return to the breeding ground in spring, some will remain
Type	Prey
Typical food	Flying insects and airborne spiders

Interesting Fact	Some swifts are among the fastest animals on the planet
Mass	5.4-184 g
Number of eggs laid	2-3
Lifespan	5.5 years
Wingspan	17 in
Information extracted from photographs	
Eye	Dark Brown
Size	Small
Length	3.5-9.8 in
Colour	sooty brown
Information extracted from Sound	
Loudness	Medium
Pitch	High-pitched sound
Duration	Medium
Regularity	Regular pattern

(Common) Blackbird	
Information extracted from text	
Natural habitat	found everywhere in gardens and countryside and from coasts to hills, although not on the highest peaks.
Nocturnal	No
Migration pattern	Mostly resident, but the blackbirds that live in northern Europe such as the Scandinavian countries, will fly south-west to spend the winter.
Type	Prey
Typical food	Insects, worms, and berries
Interesting Fact	Blackbirds typically like to sing after rain.
Mass	80-125 gr
Number of eggs laid	4
Lifespan	3 years
Wingspan	13-14 in
Information extracted from photographs	
Eye	Black with yellow eye ring
Length	10 in

Size	Medium
Male	
Colour	Glossy black plumage with blackish-brown leg
Female	
Colour	Sooty-brown plumage and brownish-white throat and some weak mottling on the breast.
Information extracted from Sound	
Loudness	Medium
Pitch	low-pitched sound
Duration	Short
Regularity	Random pattern

Barn owl	
Information extracted from text	
Natural habitat	Open Country, along field edges, riverbanks and roadside verges.
Nocturnal	Yes

Migration pattern	Young Barn Owls may disperse but adult Barn Owls are nonmigratory.
Type	Bird of prey
Typical food	Mice, voles and shrews
Interesting Fact	Barn owls have heart-shaped face that collect sounds as human ears.
Mass	290-460 g
Length	13-15 in
Number of eggs laid	2-9
Lifespan	4 years
Wingspan	34-37 in
Information extracted from photographs	
Eye	Black
Size	Large
Colour	Pale overall with a mix of buff and grey on head, back and upperwings.
Information extracted from Sound	
Loudness	Quiet

Pitch	high pitched sound
Duration	Short
Regularity	Random pattern

(Eurasian) Bullfinch	
Information extracted from text	
Natural habitat	Woodlands edges, orchard and hedgerows
Nocturnal	No
Migration pattern	Mainly resident, but many northern birds migrate further south in the winter
Type	Prey
Typical food	Seeds, buds and insects.
Interesting Fact	They form strong, lasting pair bounds and it is usual to see them in pairs throughout the year.
Mass	27-38 g
Length	6 in
Number of eggs laid	4-7

Lifespan	2 years
Wingspan	9-12 in
Information extracted from photographs	
Eye	Dark brown
Size	Small
Male	
Colour	Grey back with black wings and red breast
Female	
Colour	Brow back with black wings and pinkish-fawn breast
Information extracted from Sound	
Loudness	Quiet
Pitch	low-pitched sound
Duration	Short
Regularity	Regular pattern

Green woodpecker	
Information extracted from text	
Natural habitat	Most part of Europe and western Asia
Nocturnal	No
Migration pattern	Though these birds do not typically migrate, they can be nomadic and may wander with regard to the best food sources throughout the year.
Type	Prey
Typical food	Ants
Interesting Fact	The pair takes it in turn to incubate the eggs, with the male sitting at night.
Mass	180-220 g
Length	12-13 in
Number of eggs laid	4-6
Lifespan	5 years
Wingspan	16 in
Information extracted from photographs	
Eye	White

Size	Medium
Male	
Colour	Green upperparts, paler yellowish underparts, a red crown and red-centred moustcial stripe
Female	
Colour	Green upperparts, paler yellowish underparts, a red crown and black moustcial stripe
Information extracted from Sound	
Loudness	Loud
Pitch	low-pitched sound
Duration	Short
Regularity	Regular pattern

(Eurasian) Blackcap	
Information extracted from text	
Natural habitat	Woodland, parks and gardens
Nocturnal	No
Migration pattern	In winter, will readily come into gardens.
Type	Prey
Typical food	Insects and berries

Interesting Fact	They are know as northern nightingales.
Mass	16-25 gr
Length	5 in
Number of eggs laid	4-6
Lifespan	2 years
Wingspan	8-9 in
Information extracted from photographs	
Eye	Black
Size	Small
Male	
Crown	Black
Colour	Grey-brown upperparts and pale grey underparts
Female	
Crown	Red-brown
Colour	Brown upperparts and buff underparts
Information extracted from Sound	
Loudness	Medium
Pitch	Low-pitched sound

Duration	Short
Regularity	Random pattern

Kingfisher	
Information extracted from text	
Natural habitat	Still or slow lacks, canals and rivers.
Nocturnal	No
Migration pattern	In winter, some individuals move to estuaries and the coast.
Type	Bird of prey
Typical food	Fish and aquatic insects
Interesting Fact	There are 87 different species of kingfisher in the world, but only one breeds in Europe.
Mass	10.4 gr
Number of eggs laid	6-7
Lifespan	5-7 years
Wingspan	10 in
Information extracted from photographs	

Eye	Yellow or Orange
Size	Small
Length	3.9 in
Colour	Blue, Orange & White
Information extracted from Sound	
Loudness	Medium
Pitch	High-pitched sound
Duration	Short
Regularity	Random pattern

Lapwing	
Information extracted from text	
Natural habitat	Farmlands and wetlands

Nocturnal	Yes
Migration pattern	In winter, they flock on pasture and ploughed fields.
Type	Prey
Typical food	worms and insects
Interesting Fact	Main predators of lapwings are foxes and crows.
Mass	150-300 gr
Number of eggs laid	3-4
Lifespan	4-5 years
Wingspan	28-30 in
Information extracted from photographs	
Eye	Black
Size	Medium
Length	9-16 in
Colour	Black and white with black bill
Crown	Black
Information extracted from Sound	
Loudness	Medium
Pitch	Low-pitched sound

Duration	Medium
Regularity	Regular pattern

Meadow pipit	
Information extracted from text	
Natural habitat	Upland moors to marshes and sometimes suburban parks
Nocturnal	No
Migration pattern	In winter it moves south, to more lowland areas.
Type	Prey
Typical food	Insects, flies, beetles and spiders
Interesting Fact	Have short song for short flight
Mass	16-25 gr
Number of eggs laid	5
Lifespan	3 years
Wingspan	9-10 in
Information extracted from photographs	
Eye	Dark brown
Size	Small

Length	5.5 in
Colour	Mainly brown upperparts and buff underparts
Information extracted from Sound	
Loudness	Quiet
Pitch	Low-pitched sound
Duration	Short
Regularity	Regular pattern

Merlin	
Information extracted from text	
Natural habitat	They are often seen near coasts and upland moorlands
Nocturnal	No
Migration pattern	In winter, birds leave upland areas and come down to inland and coastal areas.
Type	Bird of prey
Typical food	Mainly small birds
Interesting Fact	The Merlin is quite unafraid, and will readily attack anything that moves conspicuously. Merlins have even been observed trying to catch automobiles and trains.

Mass	165-230 gr
Number of eggs laid	3-6
Lifespan	4-5 years
Wingspan	20-29 in
Information extracted from photographs	
Eye	Black
Size	Medium
Length	9.4-13 in
Beak	Dark
Male	
Colour	Blue-grey upperparts and buff to orange-tinted underparts
Female	
Colour	Dark brown upperparts and whitish buff spotted with brown underparts
Information extracted from Sound	
Loudness	Loud
Pitch	High-pitched sound
Duration	Short

Regularity	Regular pattern

Turtle dove	
Information extracted from text	
Natural habitat	Woodlands edges, hedgerows and open land with scattered bushes.
Nocturnal	No
Migration pattern	The turtle dove is a migratory species with a southern Palearctic range covering most of Europe and the Middle East and including Turkey and north Africa, although it is rare in northern Scandinavia and Russia. It winters in southern Africa.
Type	Prey
Typical food	Seeds
Interesting Fact	The turtle dove is Britain's only migratory dove.
Mass	130-180 g
Length	10-11 in
Number of eggs laid	1-2
Lifespan	2 years

Wingspan	19.5-22 in
Information extracted from photographs	
Eye	Yellow
Size	Medium
Colour	The throat and breast are pale pink with white underparts and brown marking on the wings.
Information extracted from Sound	
Loudness	Medium
Pitch	low-pitched sound
Duration	Medium
Regularity	Regular pattern

Slavonian grebe	
Information extracted from text	
Natural habitat	Coastal and Marine uplands
Nocturnal	No
Migration pattern	During migration, they will stop along lakes, rivers and marshes. Following migration, they winter in marine environments of estuaries and bays or inland on large lakes, although in *Norway*, large concentrations congregate on inland lakes.
Type	Waterbird
Typical food	Small fish and aquatic invertebrates
Interesting Fact	Slavonian grebe eats some of its own feathers so that they can digest fishbone.
Mass	410 g
Length	13-14 in
Number of eggs laid	3-8
Lifespan	5 years
Wingspan	21-25 in
Information extracted from photographs	
Eye	Red
Size	Medium

Colour	Red-and-black colour
Information extracted from Sound	
Loudness	Short
Pitch	low-pitched sound
Duration	Medium
Regularity	Regular pattern

Linnet	
Information extracted from text	
Natural habitat	heathland, rough ground, farmland hedges, saltmarshes and in parks
Nocturnal	No
Migration pattern	Mostly resident, but some of them migrate to south.
Type	Prey
Typical food	Seeds and insects
Interesting Fact	Common linnet eats of 46 different species of plants.
Mass	19 g
Length	5 in

Number of eggs laid	4-7
Lifespan	2 years
Wingspan	9.4 in
Information extracted from photographs	
Eye	Black
Size	Small
Colour	Brown and White
Information extracted from Sound	
Loudness	Medium
Pitch	High-pitched sound
Duration	Medium
Regularity	Random pattern

Little egret	
Information extracted from text	
Natural habitat	They are an increasingly common sight in inland areas
Nocturnal	No
Migration pattern	Northern European populations are migratory, mostly travelling to Africa although some remain in southern Europe, while some Asian populations migrate to the Philippines.
Type	Bird of prey
Typical food	Fish
Mass	450 g
Length	23 in
Number of eggs laid	3-5
Lifespan	5 years
Wingspan	36 in
Information extracted from photographs	
Eye	Black
Iris	Yellow
Size	Large

Colour	White
Leg colour	greenish-black legs
Information extracted from Sound	
Loudness	Loud
Pitch	low-pitched sound
Duration	Medium
Regularity	Regular pattern

After extraction information from the source and classifying it as subjects, predicates and objects, rdf/xml serialisation can be created.

Notice :

To avoid repeating, not all the statements will be convered in this section.

1-2 RDF/XML Serialisation

If an attribute is multivalued like natural habitat for sparrowhawks and the order is not important Bag is used and if the order was important Seq is used like size attribute. Sometimes in xml/RDF serialization datatype is considered for example for regularity pattern which is boolean) and nocturnal and this needs to be considered in the event of querying with SPARQL as well .

If we have multiple objects we can use Bag or other lists but “places” is root node and the root node should be well form, therefore we used simple predicate structure.

To avoid repeating the same statement size and loudness and length attributes are defined once in a Seq and their values are being referred by each bird. But sometimes two item in two different lists can have the same name like medium. In this case, we change the name to provide the difference in XML/RDF document.

Some birds have different attributes than the other for example some bird have crown or in some birds the color of birds between male and female species are different so in these case each individual bird have its unique type of attributes which can be queried with SPARQL for example if we want only the bird with “crown” we just have to specify the predicate and only birds with mentioned attribute will only emerge.

In some attributes like lifespan and wingspan instead of having a single value that can have a range. In this cases, web cannot access to the range if we mention them as literals so we specify to min and max attribute and for example for get the longest lifespan we just have to go through maxlifespan attributes of birds. Sometimes there is only one value in instances of these attributes as well. The way it is implemented is that we specify the same number in min and max attribute.

1-3 RDFS and terminological knowledge

At the end of the file we can add terminological knowledge. This provide more generic knowledge.

each of 4 places are subclass of places class and we can specify a class called animal and define a bird as a subclass of this class and even provide a link for further information. (each subclass is a class as well)

The relation between class and subclass exists between properties as well and we can then query these classes with SPARQL for more accurate result.

ContainerMembershipProperty indicates containedness within the elements of a list, so each predicate in a list can be an instance of this rdfs class. In the XML/RDF serialisation 3 predicate of Seq open list, get ContainerMembershipProperty class.
It is worth mentioning that other ontologies like FOAF can be imported to the projected and used as well but since this project is unique in terms of its domain we decide not to use these ontologies.

The resulted XML/RDF should be validated through W3 website to check for any error.
In the next page graph for birds is depicted and in this graph the relationship of classes is shown as rdf:type which can be used to query terminological knowledge in SPARQL.
Since at the time of validation, W3 validator was not working, we had to use http://www.easyrdf.org/converter for drawing graphs so there maybe some difference in the result graph.

XML/RDF Serialisation

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:ex="http://example.org/"
xml:base ="http://example.org/">
   <rdf:Description rdf:about="places" >
      <ex:placename rdf:resource="builtup"/>
      <ex:placename rdf:resource="countryside"/>
      <ex:placename rdf:resource="coastal"/>
      <ex:placename rdf:resource="naturereserves"/>
   </rdf:Description>
   <rdf:Description rdf:about="builtup">
      <ex:nameofbird>
       <rdf:Description rdf:about="sparrowhawks">
        <ex:naturalhabitat>
         <rdf:Bag>
          <rdf:li rdf:resource="Woodlands"/>
          <rdf:li rdf:resource="gardens"/>
          <rdf:li rdf:resource="towns"/>
          <rdf:li rdf:resource="rural areas"/>
          <rdf:li rdf:resource="starlings"/>
         </rdf:Bag>
        </ex:naturalhabitat>
          <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
           <ex:migrationpattern>From colder regions of northern Europe and Asia migrate south for the winter, some to north
Africa and India; members of the southern populations are resident or disperse.
        </ex:migrationpattern>
        <ex:type>Bird of prey</ex:type>
        <ex:typicalfood>
         <rdf:Bag>
          <rdf:li rdf:resource="finches"/>
          <rdf:li rdf:resource="sparrows"/>
          <rdf:li rdf:resource="buntings"/>
          <rdf:li rdf:resource="thrushes"/>
          <rdf:li rdf:resource="starlings"/>
         </rdf:Bag>
        </ex:typicalfood>
        <ex:interestingfact>Males move further and more often than females
         of migrating birds ringed at Kaliningrad, Russia, the average distance moved before recovery was 1,328 km for males
and 927 km for females.
        </ex:interestingfact>
        <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">110</ex:minmass>
        <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">342</ex:maxmass>
        <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlaideggs>
        <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlaideggs>
        <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlifespan>
        <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlifespan>
        <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">23</ex:minwingspan>
        <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">31</ex:maxwingspan>
```

```
 <ex:eyecolour >Yellow
 </ex:eyecolour>
 <ex:eyecolour >Orange
 </ex:eyecolour>
 <ex:size rdf:resource="median"/>
 <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">11</ex:minlength>
 <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">16</ex:maxlength>
 <ex:malecolour>
  <rdf:Description rdf:about="bodypart">
   <ex:upperpartcolour>Slate-grey</ex:upperpartcolour>
   <ex:underpartcolour>finely red-barred</ex:underpartcolour>
  </rdf:Description>
 </ex:malecolour>
 <ex:femalecolour>
  <rdf:Description rdf:about="bodypart">
   <ex:upperpartcolour>Greyish-brown</ex:upperpartcolour>
   <ex:underpartcolour>brownbarred</ex:underpartcolour>
  </rdf:Description>
 </ex:femalecolour>
  <ex:loudness rdf:resource="medium" />
  <ex:pitch>High</ex:pitch>
  <ex:duration rdf:resource="long"/>
  <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
 </rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
 <rdf:Description rdf:about="Carrion crow">
  <ex:naturalhabitat>
   <rdf:Bag>
    <rdf:li rdf:resource="Cities"/>
    <rdf:li rdf:resource="uplands"/>
    <rdf:li rdf:resource="moorlands"/>
    <rdf:li rdf:resource="woodlands"/>
    <rdf:li rdf:resource="seeshore"/>
   </rdf:Bag>
  </ex:naturalhabitat>
     <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
  <ex:migrationpattern>Mostly resident of western  Europe
  </ex:migrationpattern>
  <ex:type>Prey</ex:type>
  <ex:typicalfood rdf:resource="Scavengers by nature" />
  <ex:interestingfact>Can be tamed
  </ex:interestingfact>
  <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">370</ex:minmass>
  <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">650</ex:maxmass>
  <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:minlaideggs>
  <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:maxlaideggs>
  <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">19</ex:minlifespan>
  <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">19</ex:maxlifespan>
  <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">37</ex:minwingspan>
  <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">42</ex:maxwingspan>
  <ex:eyecolour >Black
  </ex:eyecolour>
  <ex:size rdf:resource="median" />
  <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">18</ex:minlength>
  <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">19</ex:maxlength>
  <ex:colour>
   <rdf:Description rdf:about="bodypart">
```

```
   <ex:upperpartcolour>Black</ex:upperpartcolour>
   <ex:underpartcolour>Grey</ex:underpartcolour>
  </rdf:Description>
 </ex:colour>
  <ex:loudness rdf:resource="loud"></ex:loudness>
  <ex:pitch>Low</ex:pitch>
  <ex:duration rdf:resource="long"/>
  <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
 </rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
 <rdf:Description rdf:about="swift">
 <ex:naturalhabitat rdf:resource="Rooftops" />
    <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
 <ex:migrationpattern>Migrate to Africa in winter some may return to the breeding ground in spring, some will remain
 </ex:migrationpattern>
 <ex:type>Prey</ex:type>
 <ex:typicalfood>
  <rdf:Bag>
   <rdf:li rdf:resource="Flying insects"/>
   <rdf:li rdf:resource="Airborne spiders"/>
  </rdf:Bag>
 </ex:typicalfood>
 <ex:interestingfact>Some swifts are among the fastest animals on the planet
 </ex:interestingfact>

 <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#float">5.4</ex:minmass>
 <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">184</ex:maxmass>
 <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:minlaideggs>
 <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:maxlaideggs>
 <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#float">5.5</ex:minlifespan>
 <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#float">5.5</ex:maxlifespan>
 <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">17</ex:minwingspan>
 <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">17</ex:maxwingspan>
 <ex:eyecolour>Dark Brown
 </ex:eyecolour>
 <ex:size rdf:resource="small"/>
 <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#float">3.5</ex:minlength>
 <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#float">9.8</ex:maxlength>
 <ex:colour>
  <rdf:Description rdf:about="bodypart">
   <ex:upperpartcolour>Sooty Brown</ex:upperpartcolour>
   <ex:underpartcolour>Sooty Brown</ex:underpartcolour>
  </rdf:Description>
 </ex:colour>
 <ex:loudness rdf:resource="medium" />
 <ex:pitch>High</ex:pitch>
 <ex:duration rdf:resource="mediumduration"/>
 <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
 </rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
 <rdf:Description rdf:about="Blackbird">
  <ex:naturalhabitat>
   <rdf:Bag>
    <rdf:li rdf:resource="gardens" />
    <rdf:li rdf:resource="countryside" />
    <rdf:li rdf:resource="coasts" />
```

```
        <rdf:li rdf:resource="hills" />
       </rdf:Bag>
      </ex:naturalhabitat>
      <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
          <ex:migrationpattern>Mostly resident, but the blackbirds that live in northern Europe such as the Scandinavian countries, will fly south-west to spend the winter.
      </ex:migrationpattern>
      <ex:type>Prey</ex:type>
      <ex:typicalfood>
       <rdf:Bag>
        <rdf:li rdf:resource="Insects"/>
        <rdf:li rdf:resource="worms"/>
        <rdf:li rdf:resource="berries"/>
       </rdf:Bag>
      </ex:typicalfood>
      <ex:interestingfact>Blackbirds typically like to sing after rain.
      </ex:interestingfact>
      <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">80</ex:minmass>
      <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">125</ex:maxmass>
      <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlaideggs>
      <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:maxlaideggs>
      <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:minlifespan>
      <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:maxlifespan>
      <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">13</ex:minwingspan>
      <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">14</ex:maxwingspan>
      <ex:eyecolour >Black
      </ex:eyecolour>
      <ex:eyeringcolour>Yellow</ex:eyeringcolour>
      <ex:size rdf:resource="median"/>
      <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">10</ex:minlength>
      <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">10</ex:maxlength>
      <ex:malecolour>
       <rdf:Description rdf:about="bodypart">
        <ex:plumage>Glossy Black</ex:plumage>
        <ex:leg>Blackish-brown</ex:leg>
       </rdf:Description>
      </ex:malecolour>
      <ex:femalecolour>
       <rdf:Description rdf:about="bodypart">
        <ex:plumage>Sooty-brown</ex:plumage>
        <ex:throat>brownish-white</ex:throat>
        <ex:breast>spotted</ex:breast>
       </rdf:Description>
      </ex:femalecolour>
      <ex:loudness rdf:resource="medium" />
      <ex:pitch>Low</ex:pitch>
      <ex:duration rdf:resource="short"/>
      <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:regularpattern>
     </rdf:Description>
    </ex:nameofbird>
  </rdf:Description>
  <rdf:Description rdf:about="Countryside">
    <ex:nameofbird>
     <rdf:Description rdf:about="Barn owl">
      <ex:naturalhabitat>
       <rdf:Bag>
        <rdf:li rdf:resource="opencountry"/>
        <rdf:li rdf:resource="field edges"/>
```

```
  <rdf:li rdf:resource="riverbanks"/>
  <rdf:li rdf:resource="raodsides"/>
 </rdf:Bag>
</ex:naturalhabitat>
   <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:nocturnal>
<ex:migrationpattern>young Barn owls may disperse but adult Barn owls are nonmigratory
</ex:migrationpattern>
<ex:type>Bird of prey</ex:type>
<ex:typicalfood>
 <rdf:Bag>
  <rdf:li rdf:resource="Mice"/>
  <rdf:li rdf:resource="Voles"/>
  <rdf:li rdf:resource="Shrews"/>
 </rdf:Bag>
</ex:typicalfood>
<ex:interestingfact>Barn owls have heart-shaped face that collect sounds as human ears
</ex:interestingfact>
<ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">290</ex:minmass>
<ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">460</ex:maxmass>
<ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:minlaideggs>
<ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">9</ex:maxlaideggs>
<ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlifespan>
<ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:maxlifespan>
<ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">34</ex:minwingspan>
<ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">37</ex:maxwingspan>
<ex:eyecolour >Black
</ex:eyecolour>
<ex:size rdf:resource="large"/>
<ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">13</ex:minlength>
<ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">15</ex:maxlength>
<ex:colour>
 <rdf:Description rdf:about="bodypart">
  <ex:upperwing>buff and grey</ex:upperwing>
  <ex:back>buff and grey</ex:back>
  <ex:head>buff and grey</ex:head>
  <ex:overall>pale</ex:overall>
 </rdf:Description>
</ex:colour>
 <ex:loudness rdf:resource="quiet"></ex:loudness>
 <ex:pitch>High</ex:pitch>
 <ex:duration rdf:resource="short"/>
 <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:regularpattern>
</rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
<rdf:Description rdf:about="Bullfinch">
<ex:naturalhabitat>
 <rdf:Bag>
  <rdf:li rdf:resource="woodland edges"/>
  <rdf:li rdf:resource="orchard"/>
  <rdf:li rdf:resource="hedgerows"/>
 </rdf:Bag>
</ex:naturalhabitat>
   <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
<ex:migrationpattern>Mainly resident,but many northern birds migrate further south in the winter
</ex:migrationpattern>
<ex:type>Prey</ex:type>
<ex:typicalfood>
```

<rdf:Bag>
<rdf:li rdf:resource="seeds"/>
<rdf:li rdf:resource="buds"/>
<rdf:li rdf:resource="insects"/>
</rdf:Bag>
</ex:typicalfood>
<ex:interestingfact>They form strong, lasting pair bounds and it is usual to see them in pairs throughout the year
</ex:interestingfact>
<ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">27</ex:minmass>
<ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">38</ex:maxmass>
<ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlaideggs>
<ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">7</ex:maxlaideggs>
<ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:minlifespan>
<ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:maxlifespan>
<ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">9</ex:minwingspan>
<ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">12</ex:maxwingspan>
<ex:eyecolour >Dark Brown
</ex:eyecolour>
<ex:size rdf:resource="small"/>
<ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">6</ex:minlength>
<ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">6</ex:maxlength>
<ex:malecolour>
<rdf:Description rdf:about="bodypart">
<ex:back>Grey</ex:back>
<ex:wing>Black</ex:wing>
<ex:breast>Red</ex:breast>
</rdf:Description>
</ex:malecolour>
<ex:femalecolour>
<rdf:Description rdf:about="bodypart">
<ex:back>Brow</ex:back>
<ex:wing>Black</ex:wing>
<ex:breast>Pinkish-fawn</ex:breast>
</rdf:Description>
</ex:femalecolour>
<ex:loudness rdf:resource="quiet"></ex:loudness>
<ex:pitch>Low</ex:pitch>
<ex:duration rdf:resource="short"/>
<ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
</rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
<rdf:Description rdf:about="Green woodpecker">
<ex:naturalhabitat rdf:resource="EuropeandwesternAsia" />
<ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
<ex:migrationpattern>Though these birds do not typically migrate, they can be nomadic and may wander with regard to the best food sources throughout the year.
</ex:migrationpattern>
<ex:type>Prey</ex:type>
<ex:typicalfood rdf:resource="Ants" />
<ex:interestingfact>The pair takes it in turn to incubate the eggs, with the male sitting at night.
</ex:interestingfact>
<ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">180</ex:minmass>
<ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">220</ex:maxmass>
<ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlaideggs>
<ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">6</ex:maxlaideggs>
<ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:minlifespan>
<ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlifespan>

```
<ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">16</ex:minwingspan>
<ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">16</ex:maxwingspan>
<ex:eyecolour>White
</ex:eyecolour>
<ex:size rdf:resource="median" />
<ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">12</ex:minlength>
<ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">13</ex:maxlength>
<ex:malecolour>
 <rdf:Description rdf:about="bodypart">
  <ex:upperpartcolour>Green</ex:upperpartcolour>
  <ex:underpartcolour>pale and yellowish</ex:underpartcolour>
  <ex:crowncolour>Red</ex:crowncolour>
  <ex:stripes>red-centred</ex:stripes>
 </rdf:Description>
</ex:malecolour>
<ex:femalecolour>
 <rdf:Description rdf:about="bodypart">
  <ex:upperpartcolour>Green</ex:upperpartcolour>
  <ex:underpartcolour>pale and yellowish</ex:underpartcolour>
  <ex:crowncolour>Red</ex:crowncolour>
  <ex:stripes>Black</ex:stripes>
 </rdf:Description>
</ex:femalecolour>
<ex:loudness rdf:resource="loud"></ex:loudness>
<ex:pitch>Low</ex:pitch>
<ex:duration rdf:resource="short"/>
<ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
</rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
 <rdf:Description rdf:about="Blackcap">
 <ex:naturalhabitat>
  <rdf:Bag>
   <rdf:li rdf:resource="gardens" />
   <rdf:li rdf:resource="parks" />
   <rdf:li rdf:resource="woodlands" />
  </rdf:Bag>
 </ex:naturalhabitat>
 <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
 <ex:migrationpattern>In winter, will readily come into gardens.
 </ex:migrationpattern>
 <ex:type>Prey</ex:type>
 <ex:typicalfood>
  <rdf:Bag>
   <rdf:li rdf:resource="Insects"/>
   <rdf:li rdf:resource="Berries"/>
  </rdf:Bag>
 </ex:typicalfood>
 <ex:interestingfact>They are know as northern nightingales.
 </ex:interestingfact>
 <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">16</ex:minmass>
 <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">25</ex:maxmass>
 <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlaideggs>
 <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">6</ex:maxlaideggs>
 <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:minlifespan>
 <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:maxlifespan>
 <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">8</ex:minwingspan>
 <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">9</ex:maxwingspan>
```

```
      <ex:eyecolour >Black
      </ex:eyecolour>
      <ex:size rdf:resource="small"/>
      <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:minlength>
      <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlength>
      <ex:malecolour>
       <rdf:Description rdf:about="bodypart">
        <ex:crown>Black</ex:crown>
        <ex:upperpartcolour>Grey-brown</ex:upperpartcolour>
        <ex:underpartcolour>pale grey</ex:underpartcolour>
       </rdf:Description>
      </ex:malecolour>
      <ex:femalecolour>
       <rdf:Description rdf:about="bodypart">
        <ex:crown>Red-brown</ex:crown>
        <ex:upperpartcolour>Brown</ex:upperpartcolour>
        <ex:underpartcolour>Buff</ex:underpartcolour>
       </rdf:Description>
      </ex:femalecolour>
      <ex:loudness rdf:resource="medium" />
      <ex:pitch>Low</ex:pitch>
      <ex:duration rdf:resource="short"/>
      <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:regularpattern>
     </rdf:Description>
    </ex:nameofbird>
</rdf:Description>
<rdf:Description rdf:about="Coastal">
    <ex:nameofbird>
     <rdf:Description rdf:about="Kingfisher">
      <ex:naturalhabitat>
       <rdf:Bag>
        <rdf:li rdf:resource="Lacks"/>
        <rdf:li rdf:resource="canals"/>
        <rdf:li rdf:resource="rivers"/>
       </rdf:Bag>
      </ex:naturalhabitat>
        <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
      <ex:migrationpattern>In winter, some individuals move to estuaries and the coast.
      </ex:migrationpattern>
      <ex:type>Bird of prey</ex:type>
      <ex:typicalfood>
       <rdf:Bag>
        <rdf:li rdf:resource="fish"/>
        <rdf:li rdf:resource="Aquatic insects"/>
       </rdf:Bag>
      </ex:typicalfood>
      <ex:interestingfact>There are 87 different species of  kingfisher in the world, but only one breeds in Europe.
      </ex:interestingfact>
      <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#float">10.4</ex:minmass>
      <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#float">10.4</ex:maxmass>
      <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">6</ex:minlaideggs>
      <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">7</ex:maxlaideggs>
      <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:minlifespan>
      <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">7</ex:maxlifespan>
      <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">10</ex:minwingspan>
      <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">10</ex:maxwingspan>
      <ex:eyecolour >Yellow
      </ex:eyecolour>
```

```
 <ex:eyecolour >Orange
 </ex:eyecolour>
 <ex:size rdf:resource="small"/>
 <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#float">3.9</ex:minlength>
 <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#float">3.9</ex:maxlength>
 <ex:colour>Blue</ex:colour>
 <ex:colour>Orange</ex:colour>
 <ex:colour>White</ex:colour>
 <ex:loudness rdf:resource="medium" />
 <ex:pitch>High</ex:pitch>
 <ex:duration rdf:resource="short" />
 <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:regularpattern>
 </rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
 <rdf:Description rdf:about="Lapwing">
 <ex:naturalhabitat>
  <rdf:Bag>
   <rdf:li rdf:resource="Farmlands"/>
   <rdf:li rdf:resource="Wetlands"/>
  </rdf:Bag>
 </ex:naturalhabitat>
    <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:nocturnal>
 <ex:migrationpattern>In winter, they flock on pasture and ploughed fields.
 </ex:migrationpattern>
 <ex:type>Prey</ex:type>
 <ex:typicalfood>
  <rdf:Bag>
   <rdf:li rdf:resource="Worms"/>
   <rdf:li rdf:resource="Insects"/>
  </rdf:Bag>
 </ex:typicalfood>
 <ex:interestingfact>Main predators of lapwings are foxes and crows.
 </ex:interestingfact>
 <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">150</ex:minmass>
 <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">300</ex:maxmass>
 <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:minlaideggs>
 <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:maxlaideggs>
 <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlifespan>
 <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlifespan>
 <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">28</ex:minwingspan>
 <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">30</ex:maxwingspan>
 <ex:eyecolour >Black
 </ex:eyecolour>
 <ex:size rdf:resource="median" />
 <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">9</ex:minlength>
 <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">16</ex:maxlength>
 <ex:colour>Black and white</ex:colour>
 <ex:bill>Black</ex:bill>
 <ex:crwon>Black</ex:crwon>
 <ex:loudness rdf:resource="medium" />
 <ex:pitch>Low</ex:pitch>
 <ex:duration rdf:resource="mediumduration"/>
 <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
 </rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
 <rdf:Description rdf:about="Meadow pipit">
```

<ex:naturalhabitat>
<rdf:Bag>
<rdf:li rdf:resource="Uplands"/>
<rdf:li rdf:resource="Moors"/>
<rdf:li rdf:resource="Marshes"/>
<rdf:li rdf:resource="Suburbanparks"/>
</rdf:Bag>
</ex:naturalhabitat>
<ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
<ex:migrationpattern>In winter it moves south, to more lowland areas.
</ex:migrationpattern>
<ex:type>Prey</ex:type>
<ex:typicalfood>
<rdf:Bag>
<rdf:li rdf:resource="Insects"/>
<rdf:li rdf:resource="Flies"/>
<rdf:li rdf:resource="Beetles"/>
<rdf:li rdf:resource="Spiders"/>
</rdf:Bag>
</ex:typicalfood>
<ex:interestingfact>Have short song for short flight
</ex:interestingfact>
<ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">16</ex:minmass>
<ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">25</ex:maxmass>
<ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:minlaideggs>
<ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlaideggs>
<ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:minlifespan>
<ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:maxlifespan>
<ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">9</ex:minwingspan>
<ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">10</ex:maxwingspan>
<ex:eyecolour>Dark Brown
</ex:eyecolour>
<ex:size rdf:resource="small"/>
<ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#float">5.5</ex:minlength>
<ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#float">5.8</ex:maxlength>
<ex:colour>
<rdf:Description rdf:about="bodypart">
<ex:upperpartcolour>Brown</ex:upperpartcolour>
<ex:underpartcolour>Buff</ex:underpartcolour>
</rdf:Description>
</ex:colour>
<ex:loudness rdf:resource="quiet"></ex:loudness>
<ex:pitch>Low</ex:pitch>
<ex:duration rdf:resource="short"/>
<ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
</rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
<rdf:Description rdf:about="Merlin">
<ex:naturalhabitat>
<rdf:Bag>
<rdf:li rdf:resource="coasts" />
<rdf:li rdf:resource="uplands" />
<rdf:li rdf:resource="moorlands" />
</rdf:Bag>
</ex:naturalhabitat>
<ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
<ex:migrationpattern>In winter, birds leave upland areas and come down to inland and coastal areas.

```
        </ex:migrationpattern>
        <ex:type>Bird of prey</ex:type>
        <ex:typicalfood>Small Birds</ex:typicalfood>
          <ex:interestingfact>The Merlin is quite unafraid, and will readily attack anything that moves conspicuously. Merlins
have even been observed trying to catch automobiles and trains.
        </ex:interestingfact>
        <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">165</ex:minmass>
        <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">230</ex:maxmass>
        <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:minlaideggs>
        <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">6</ex:maxlaideggs>
        <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlifespan>
        <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlifespan>
        <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">20</ex:minwingspan>
        <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">29</ex:maxwingspan>
        <ex:eyecolour >Black
        </ex:eyecolour>
        <ex:size rdf:resource="median"/>
        <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#float">9.4</ex:minlength>
        <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">13</ex:maxlength>
        <ex:malecolour>
         <rdf:Description rdf:about="bodypart">
          <ex:upperpartcolour>Blue-grey</ex:upperpartcolour>
          <ex:underpartcolour>Buff to orange-tinted</ex:underpartcolour>
         </rdf:Description>
        </ex:malecolour>
        <ex:femalecolour>
         <rdf:Description rdf:about="bodypart">
           <ex:upperpartcolour>Dark brown</ex:upperpartcolour>
          <ex:underpartcolour>whitish buff spotted with brown</ex:underpartcolour>
         </rdf:Description>
        </ex:femalecolour>
        <ex:loudness rdf:resource="loud"></ex:loudness>
        <ex:pitch>High</ex:pitch>
        <ex:duration rdf:resource="short"/>
        <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
       </rdf:Description>
      </ex:nameofbird>
   </rdf:Description>
   <rdf:Description rdf:about="naturereserves">
      <ex:nameofbird>
       <rdf:Description rdf:about="Turtle dove">
        <ex:naturalhabitat>
         <rdf:Bag>
          <rdf:li rdf:resource="Woodlands edges"/>
          <rdf:li rdf:resource="Hedgerows"/>
          <rdf:li rdf:resource="Open lands"/>
          <rdf:li rdf:resource="scattered bushes"/>
         </rdf:Bag>
        </ex:naturalhabitat>
          <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
         <ex:migrationpattern>The turtle dove is a migratory species with a southern Palearctic range covering most of Europe
and the Middle East and including Turkey and north Africa, although it is rare in northern Scandinavia and Russia. It winters
in southern Africa.
        </ex:migrationpattern>
        <ex:type>Prey</ex:type>
        <ex:typicalfood rdf:resource="seeds" />
        <ex:interestingfact>The turtle dove is Britain’s only migratory dove.
        </ex:interestingfact>
```

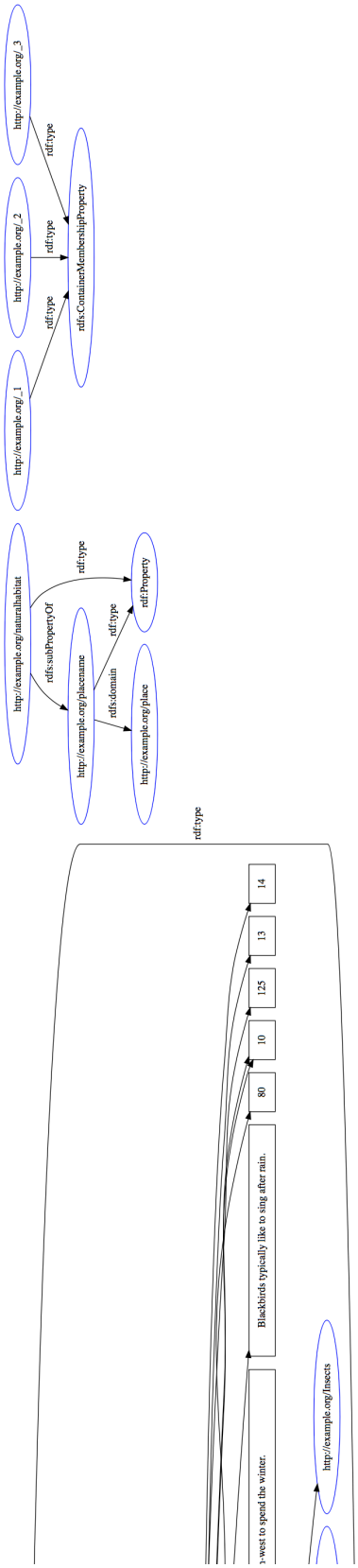
<ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">130</ex:minmass>
<ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">118</ex:maxmass>
<ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">1</ex:minlaideggs>
<ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:maxlaideggs>
<ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:minlifespan>
<ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:maxlifespan>
<ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#float">19.5</ex:minwingspan>
<ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">22</ex:maxwingspan>
<ex:eyecolour >Yellow
</ex:eyecolour>
<ex:size rdf:resource="median" />
<ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">10</ex:minlength>
<ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">11</ex:maxlength>
<ex:colour>
<rdf:Description rdf:about="bodypart">
<ex:throat>Pale pink</ex:throat>
<ex:breast>Pale pink</ex:breast>
<ex:underpartcolour>white</ex:underpartcolour>
<ex:wing>brown marking</ex:wing>
</rdf:Description>
</ex:colour>
<ex:loudness rdf:resource="medium" />
<ex:pitch>Low</ex:pitch>
<ex:duration rdf:resource="mediumduration"/>
<ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
</rdf:Description>
</ex:nameofbird>
<ex:nameofbird>
<rdf:Description rdf:about="Slavonian grebe">
<ex:naturalhabitat>
<rdf:Bag>
<rdf:li rdf:resource="Coastal uplands"/>
<rdf:li rdf:resource="Marine uplands"/>
</rdf:Bag>
</ex:naturalhabitat>
<ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
<ex:migrationpattern>During migration, they will stop along lakes, rivers and marshes. Following migration, they winter in marine environments of estuaries and bays or inland on large lakes, although in Norway, large concentrations congregate on inland lakes.
</ex:migrationpattern>
<ex:type>Waterbird</ex:type>
<ex:typicalfood>
<rdf:Bag>
<rdf:li rdf:resource="Smallfish"/>
<rdf:li rdf:resource="aquaticinvertebrates"/>
</rdf:Bag>
</ex:typicalfood>
<ex:interestingfact>Slavonian grebe eats some of its own feathers so that they can digest fishbone.
</ex:interestingfact>
<ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">410</ex:minmass>
<ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">410</ex:maxmass>
<ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:minlaideggs>
<ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">8</ex:maxlaideggs>
<ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:minlifespan>
<ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlifespan>
<ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">21</ex:minwingspan>
<ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">25</ex:maxwingspan>
<ex:eyecolour >Red

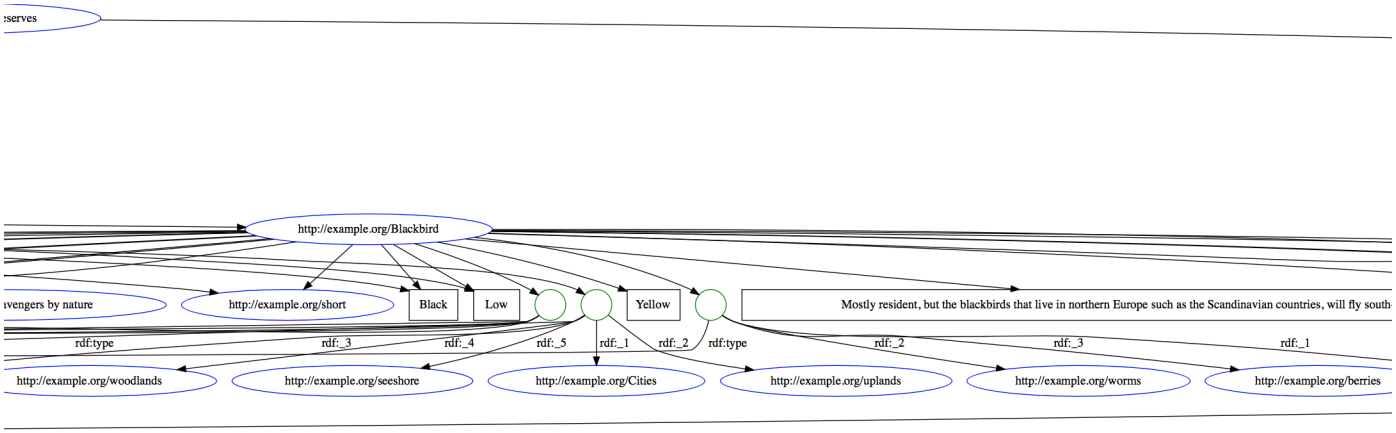
```
 </ex:eyecolour>
 <ex:size rdf:resource="median" />
 <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">13</ex:minlength>
 <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">14</ex:maxlength>
 <ex:colour>Red-and-black colour
 </ex:colour>
 <ex:loudness rdf:resource="short"></ex:loudness>
 <ex:pitch>Low</ex:pitch>
 <ex:duration rdf:resource="mediumduration"/>
 <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
 </rdf:Description>
 </ex:nameofbird>
<ex:nameofbird>
 <rdf:Description rdf:about="Linnet">
<ex:naturalhabitat>
  <rdf:Bag>
   <rdf:li rdf:resource="Heatland"/>
   <rdf:li rdf:resource="Rough ground"/>
   <rdf:li rdf:resource="Farmland hedges"/>
   <rdf:li rdf:resource="Salt Marshes"/>
   <rdf:li rdf:resource="Parks"/>
  </rdf:Bag>
</ex:naturalhabitat>
    <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
 <ex:migrationpattern>Mostly resident, but some of them migrate to south.
 </ex:migrationpattern>
 <ex:type>Prey</ex:type>
 <ex:typicalfood>
  <rdf:Bag>
   <rdf:li rdf:resource="Seeds"/>
   <rdf:li rdf:resource="Insects"/>
  </rdf:Bag>
 </ex:typicalfood>
 <ex:interestingfact>Common linnet eats of 46 different species of plants.
 </ex:interestingfact>
 <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">19</ex:minmass>
 <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">19</ex:maxmass>
 <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">4</ex:minlaideggs>
 <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">7</ex:maxlaideggs>
 <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:minlifespan>
 <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">2</ex:maxlifespan>
 <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#float">9.4</ex:minwingspan>
 <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#float">9.4</ex:maxwingspan>
 <ex:eyecolour>Black
 </ex:eyecolour>
 <ex:size rdf:resource="small"/>
 <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:minlength>
 <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlength>
 <ex:colour>Brown
 </ex:colour>
 <ex:colour>White
 </ex:colour>
  <ex:loudness rdf:resource="medium" />
  <ex:pitch>High</ex:pitch>
  <ex:duration rdf:resource="mediumduration"/>
  <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:regularpattern>
      </rdf:Description>
</ex:nameofbird>
```

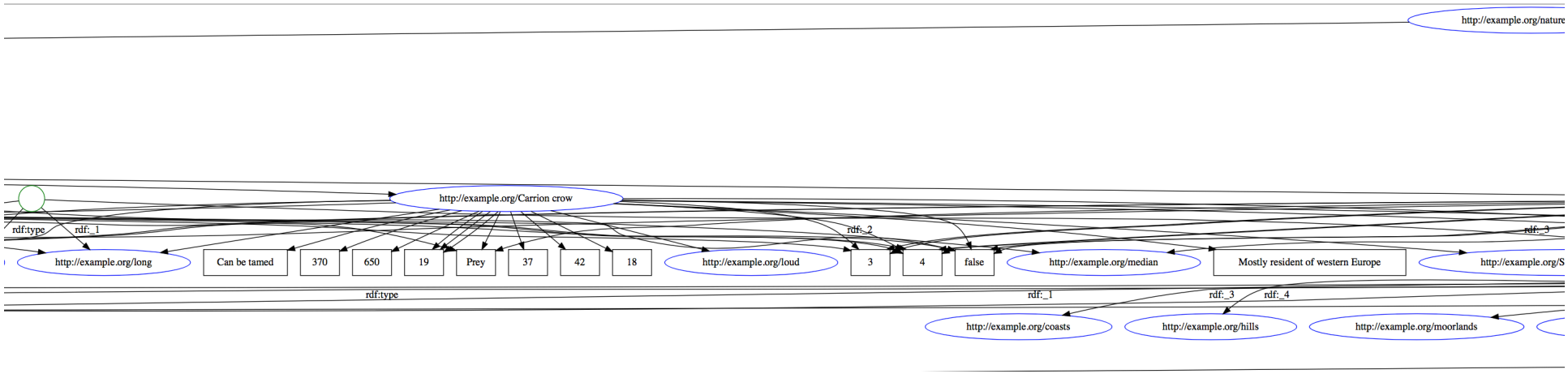
```
      <ex:nameofbird>
       <rdf:Description rdf:about="Little egret">
        <ex:naturalhabitat rdf:resource="inlands" />
        <ex:nocturnal rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">false</ex:nocturnal>
         <ex:migrationpattern>Northern European populations are migratory, mostly travelling to Africa although some remain
in southern Europe, while some Asian populations migrate to the Philippines.
        </ex:migrationpattern>
        <ex:type>Bird of prey</ex:type>
        <ex:typicalfood rdf:resource="Fish" />
        <ex:minmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">450</ex:minmass>
        <ex:maxmass rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">450</ex:maxmass>
        <ex:minlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">3</ex:minlaideggs>
        <ex:maxlaideggs rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlaideggs>
        <ex:minlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:minlifespan>
        <ex:maxlifespan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">5</ex:maxlifespan>
        <ex:minwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">36</ex:minwingspan>
        <ex:maxwingspan rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">36</ex:maxwingspan>
        <ex:eyecolour >Black
        </ex:eyecolour>
        <ex:iriscolour>Yellow</ex:iriscolour>
        <ex:size rdf:resource="large"/>
        <ex:maxlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">23</ex:maxlength>
        <ex:minlength rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">23</ex:minlength>
        <ex:colour>
         <rdf:Description rdf:about="bodypart">
          <ex:overall>White</ex:overall>
          <ex:leg>greenish-black</ex:leg>
         </rdf:Description>
        </ex:colour>
        <ex:loudness rdf:resource="loud" />
        <ex:pitch>Low</ex:pitch>
        <ex:duration rdf:resource="mediumduration"/>
        <ex:regularpattern rdf:datatype="http://www.w3.org/2001/XMLSchema#boolean">true</ex:regularpattern>
       </rdf:Description>
      </ex:nameofbird>
   </rdf:Description>

        <rdf:Seq>
            <rdf:li rdf:resource="large"/>
            <rdf:li rdf:resource="median"/>
            <rdf:li rdf:resource="small"/>
        </rdf:Seq>
        <rdf:Seq>
            <rdf:li rdf:resource="loud"/>
            <rdf:li rdf:resource="medium"/>
            <rdf:li rdf:resource="quiet"/>
            </rdf:Seq>
        <rdf:Seq>
            <rdf:li rdf:resource="long"/>
            <rdf:li rdf:resource="mediumduration"/>
            <rdf:li rdf:resource="short"/>
        </rdf:Seq>

<!--This is rdf schema part of the document-->


<rdfs:Class rdf:about="places">
</rdfs:Class>
```

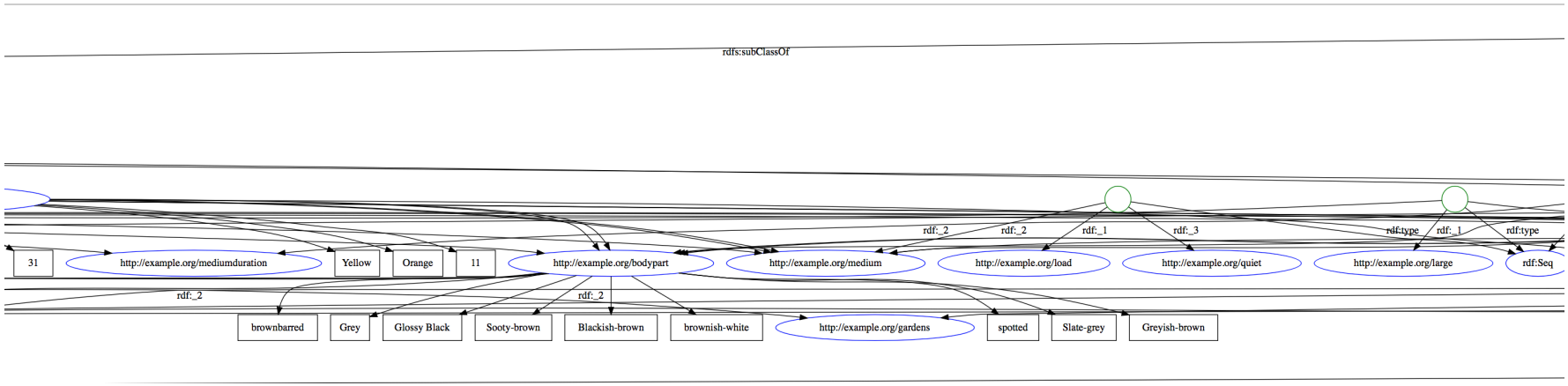
```
<rdfs:Class rdf:about="builtup">
   <rdfs:subClassOf rdf:resource="places"/>
</rdfs:Class>
<rdfs:Class rdf:about="countryside">
   <rdfs:subClassOf rdf:resource="places"/>
</rdfs:Class>
<rdfs:Class rdf:about="coastal">
   <rdfs:subClassOf rdf:resource="places"/>
</rdfs:Class>
<rdfs:Class rdf:about="naturereserves">
   <rdfs:subClassOf rdf:resource="places"/>
</rdfs:Class>
<rdfs:Class rdf:about="animal">
</rdfs:Class>
<rdfs:Class rdf:about="sparrowhawks">
   <rdfs:subClassOf rdf:resource="animal"/>
   <rdfs:seeAlso rdf:resource="http://www.rspb.org.uk"/>
</rdfs:Class>
   <rdfs:Class rdf:about="swift">
   <rdfs:subClassOf rdf:resource="animal"/>
   <rdfs:seeAlso rdf:resource="http://www.rspb.org.uk"/>
</rdfs:Class>
<rdf:Property rdf:about="placename">
      <rdfs:domain rdf:resource="place"/>
</rdf:Property>
<rdf:Property rdf:about="naturalhabitat">
      <rdfs:subPropertyOf rdf:resource="placename"/>
</rdf:Property>
<rdfs:ContainerMembershipProperty rdf:about="_1">
</rdfs:ContainerMembershipProperty>
<rdfs:ContainerMembershipProperty rdf:about="_2">
</rdfs:ContainerMembershipProperty>
<rdfs:ContainerMembershipProperty rdf:about="_3">
</rdfs:ContainerMembershipProperty>
</rdf:RDF>
```

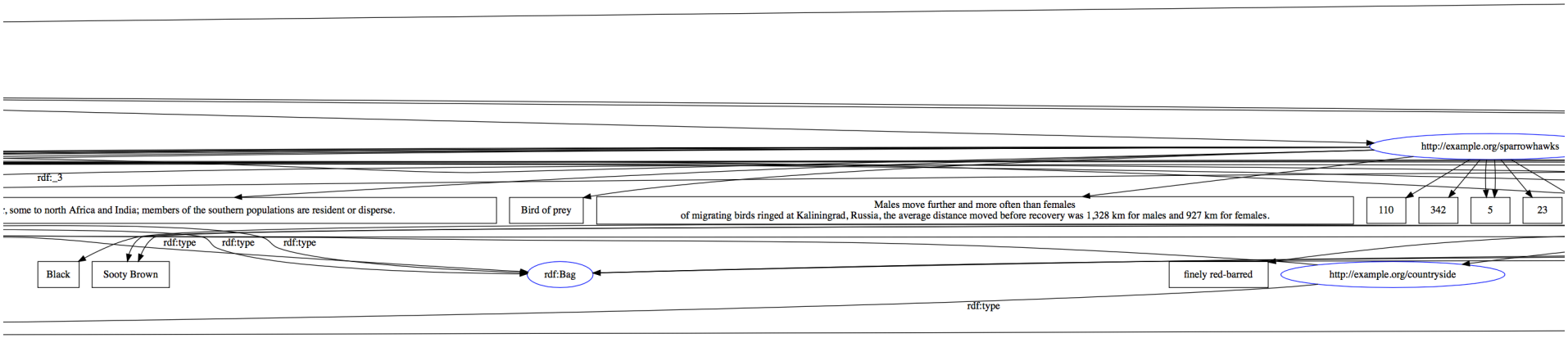
Great number of nodes hamper the readability of the resulting graph so for demonstration purpose first a graph for 4 birds is shown and then the full graph will be illustrated.

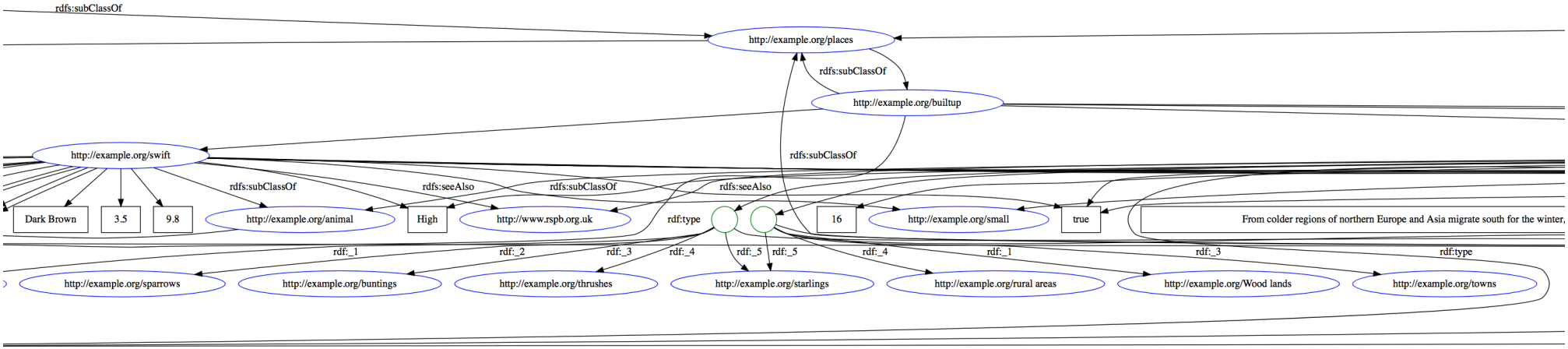



:serves
http://example.org/Blackbird
ıvengers by nature
http://example.org/short
Black
Low
Yellow
Mostly resident, but the blackbirds that live in northern Europe such as the Scandinavian countries, will fly south
rdf:type
rdf:_3
rdf:_4
rdf:_5
rdf:_1
rdf:_2
rdf:type
rdf:_2
rdf:_3
rdf:_1
http://example.org/woodlands
http://example.org/seeshore
http://example.org/Cities
http://example.org/uplands
http://example.org/worms
http://example.org/berries


http://example.org/nature
http://example.org/Carrion crow
rdf:type
rdf:_1
rdf:_2
rdf:_3
http://example.org/long
Can be tamed
370
650
19
Prey
37
42
18
http://example.org/loud
3
4
false
http://example.org/median
Mostly resident of western Europe
http://example.org/S
rdf:type
rdf:_1
rdf:_3
rdf:_4
http://example.org/coasts
http://example.org/hills
http://example.org/moorlands

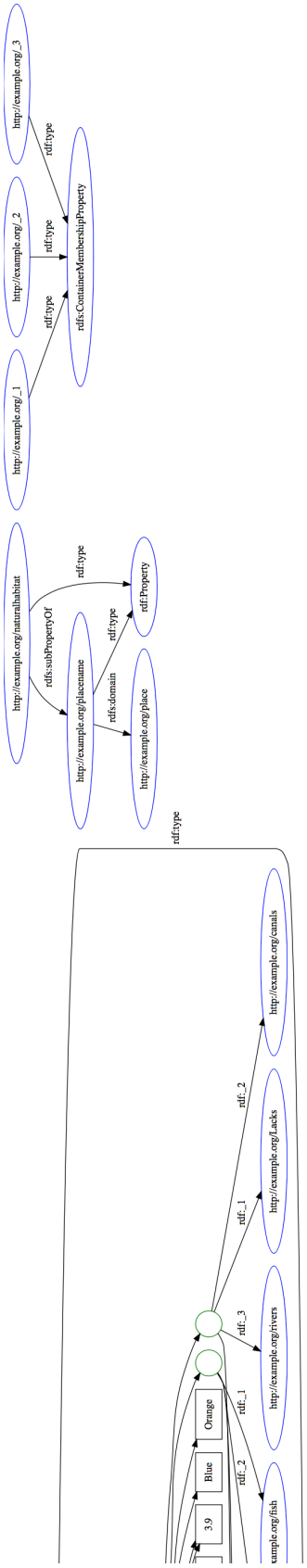

rdfs:subClassOf
rdf:_2
rdf:_2
rdf:_1
rdf:_3
rdf:type
rdf:_1
rdf:type
31
http://example.org/mediumduration
Yellow
Orange
11
http://example.org/bodypart
http://example.org/medium
http://example.org/load
http://example.org/quiet
http://example.org/large
rdf:Seq
rdf:_2
rdf:_2
brownbarred
Grey
Glossy Black
Sooty-brown
Blackish-brown
brownish-white
http://example.org/gardens
spotted
Slate-grey
Greyish-brown

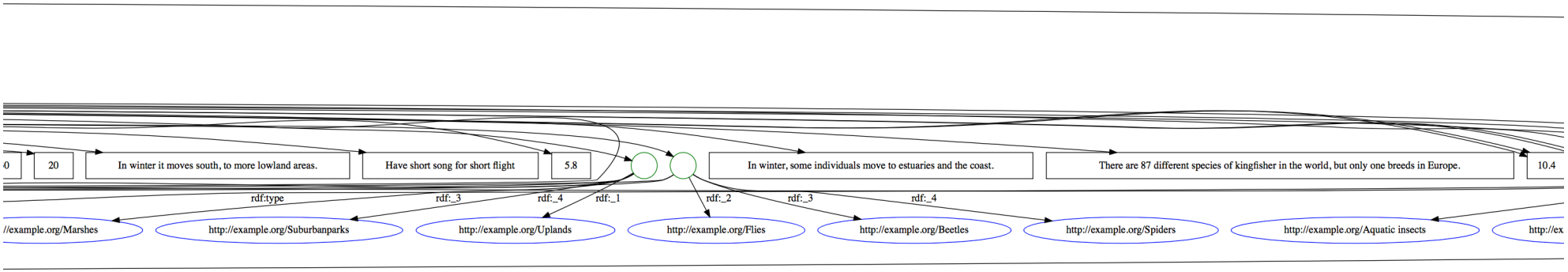

http://example.org/sparrowhawks
rdf:_3
, some to north Africa and India; members of the southern populations are resident or disperse.
Bird of prey
Males move further and more often than females
of migrating birds ringed at Kaliningrad, Russia, the average distance moved before recovery was 1,328 km for males and 927 km for females.
110
342
5
23
rdf:type
rdf:type
rdf:type
Black
Sooty Brown
rdf:Bag
finely red-barred
http://example.org/countryside
rdf:type

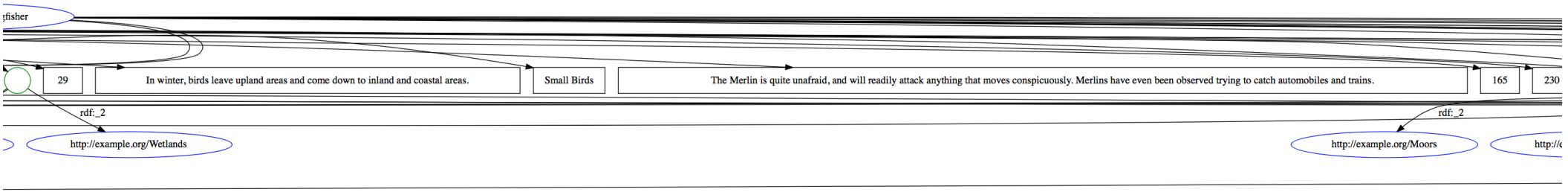

rdfs:subClassOf
http://example.org/places
rdfs:subClassOf
http://example.org/builtup
http://example.org/swift
rdfs:subClassOf
rdfs:subClassOf
rdfs:seeAlso
rdfs:subClassOf
rdfs:seeAlso
Dark Brown
3.5
9.8
http://example.org/animal
High
http://www.rspb.org.uk
rdf:type
16
http://example.org/small
true
From colder regions of northern Europe and Asia migrate south for the winter,
rdf:_1
rdf:_2
rdf:_3
rdf:_4
rdf:_5
rdf:_5
rdf:_4
rdf:_1
rdf:_3
rdf:type
http://example.org/sparrows
http://example.org/buntings
http://example.org/thrushes
http://example.org/starlings
http://example.org/rural areas
http://example.org/Wood lands
http://example.org/towns

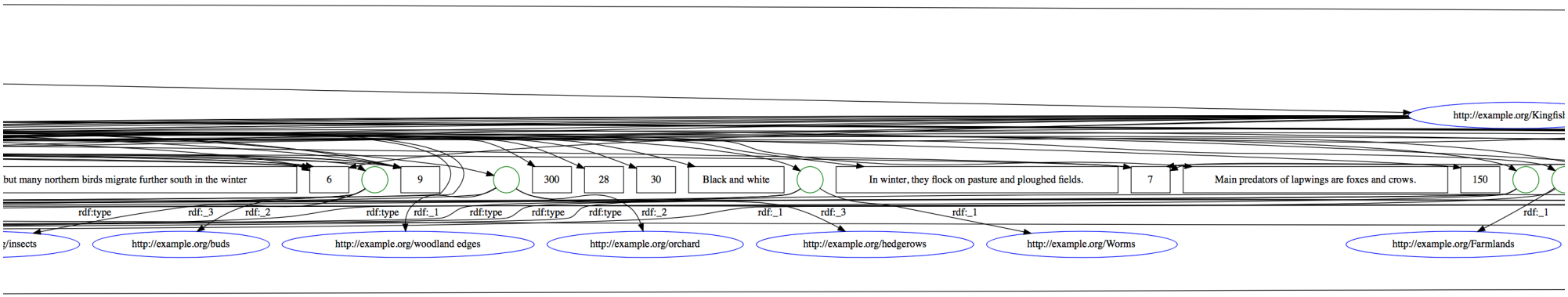

http://example.org/coastal
rdf:type
rdf:type
http://example.org/Rooftops
Migrate to Africa in winter some may return to the breeding ground in spring, some will remain
Some swifts are among the fastest animals on the planet
5.4
184
2
5.5
17
rdf:type
rdf:_2
rdf:_1
http://example.org/Airborne spiders
http://example.org/Flying insects
rdf:type
http://example.org/finches
rdfs:Class

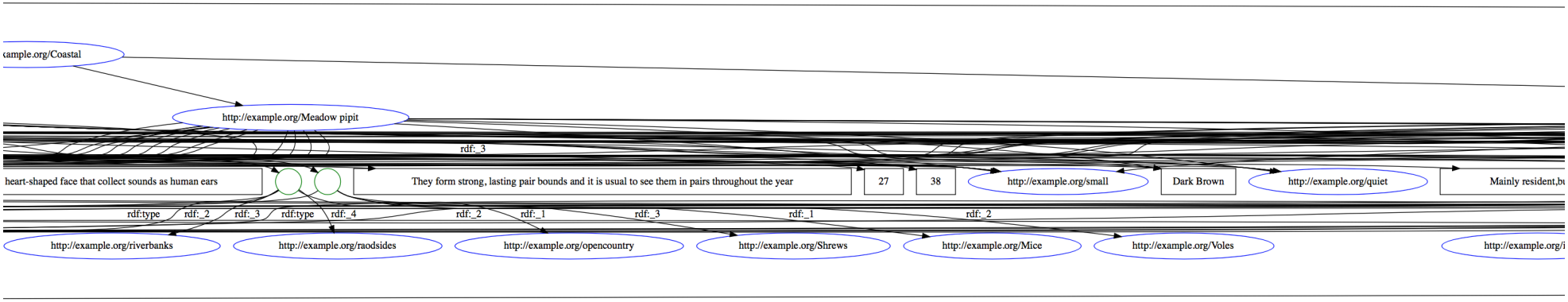
Full Graph

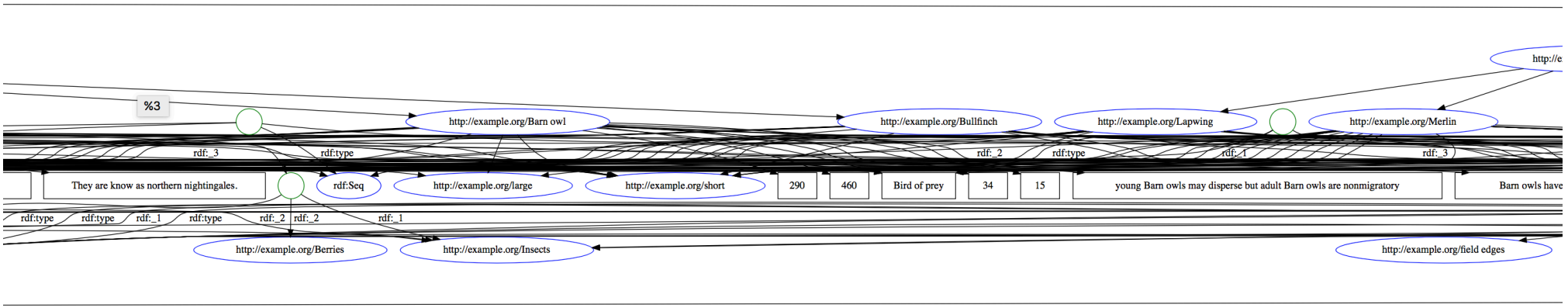

http://example.org/_3
rdf:type
http://example.org/_2
rdf:type
rdfs:ContainerMembershipProperty
http://example.org/_1
rdf:type
http://example.org/naturalhabitat
rdf:type
rdfs:subPropertyOf
rdf:Property
http://example.org/placename
rdf:type
rdfs:domain
http://example.org/place
rdf:type
http://example.org/canals
rdf:_2
http://example.org/Lacks
rdf:_1
rdf:_3
http://example.org/rivers
rdf:_1
Orange
rdf:_2
Blue
3.9
sample.org/fish

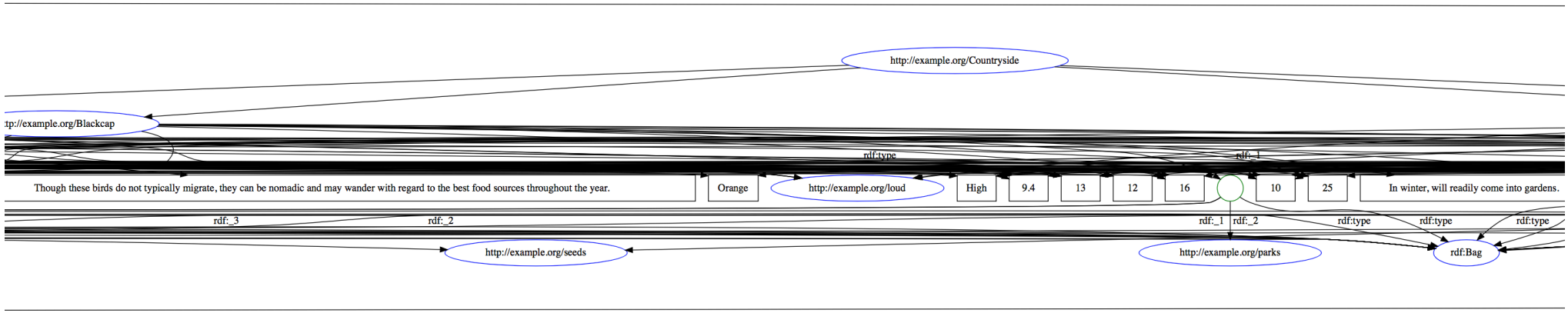

0
20
In winter it moves south, to more lowland areas.
Have short song for short flight
5.8
In winter, some individuals move to estuaries and the coast.
There are 87 different species of kingfisher in the world, but only one breeds in Europe.
10.4
rdf:type
rdf:_3
rdf:_4
rdf:_1
rdf:_2
rdf:_3
rdf:_4
//example.org/Marshes
http://example.org/Suburbanparks
http://example.org/Uplands
http://example.org/Flies
http://example.org/Beetles
http://example.org/Spiders
http://example.org/Aquatic insects
http://ex

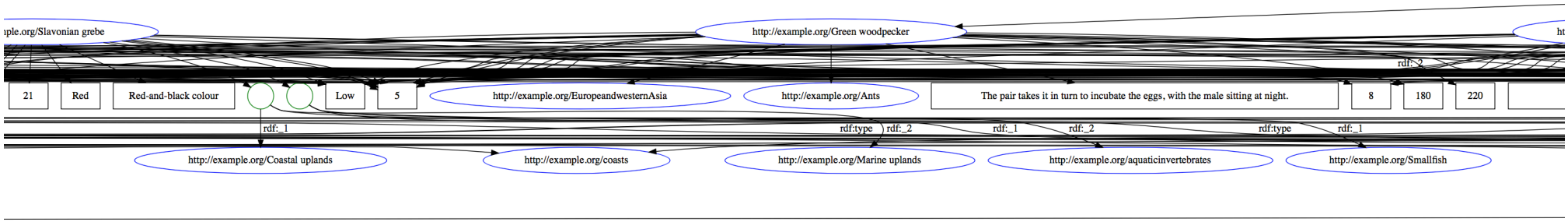

ɣfisher
29
In winter, birds leave upland areas and come down to inland and coastal areas.
Small Birds
The Merlin is quite unafraid, and will readily attack anything that moves conspicuously. Merlins have even been observed trying to catch automobiles and trains.
165
230
rdf:_2
rdf:_2
http://example.org/Wetlands
http://example.org/Moors
http://e

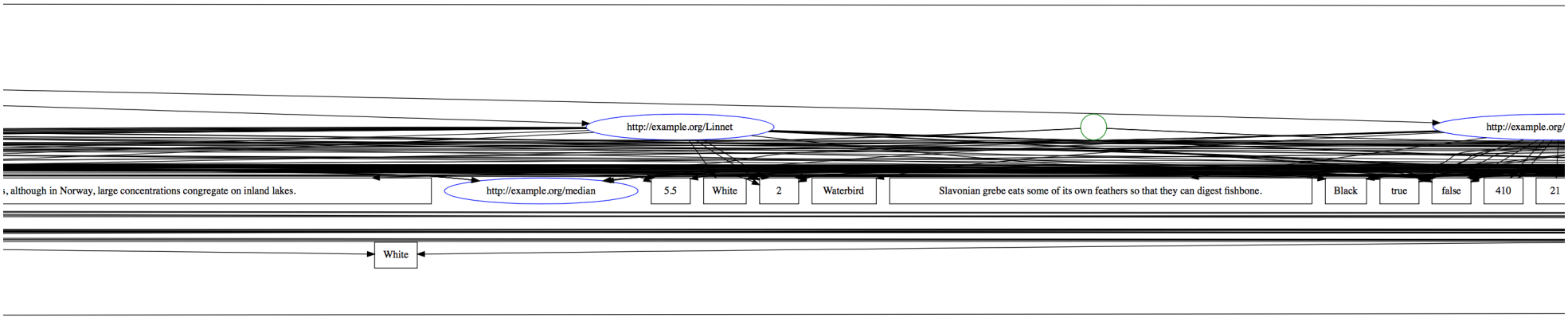

http://example.org/Kingfish
but many northern birds migrate further south in the winter
6
9
300
28
30
Black and white
In winter, they flock on pasture and ploughed fields.
7
Main predators of lapwings are foxes and crows.
150
rdf:type
rdf:_3
rdf:_2
rdf:type
rdf:_1
rdf:type
rdf:type
rdf:type
rdf:_2
rdf:_1
rdf:_3
rdf:_1
rdf:_1
/insects
http://example.org/buds
http://example.org/woodland edges
http://example.org/orchard
http://example.org/hedgerows
http://example.org/Worms
http://example.org/Farmlands

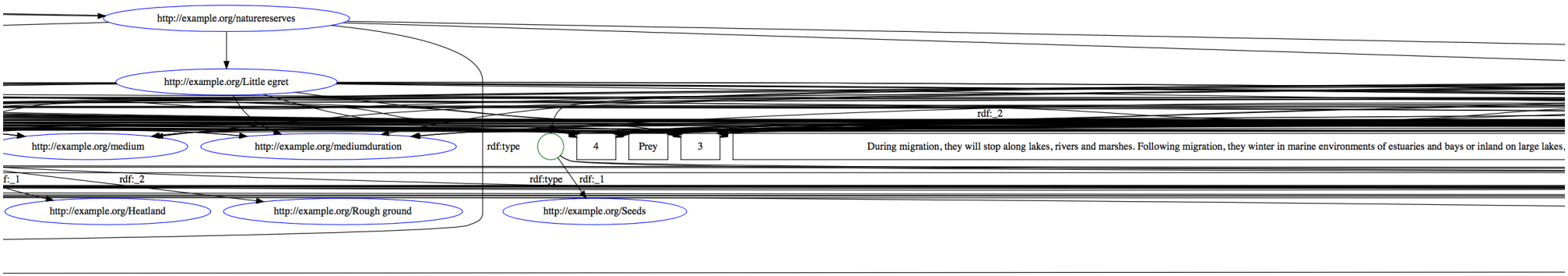

ample.org/Coastal
http://example.org/Meadow pipit
rdf:_3
heart-shaped face that collect sounds as human ears
They form strong, lasting pair bounds and it is usual to see them in pairs throughout the year
27
38
http://example.org/small
Dark Brown
http://example.org/quiet
Mainly resident,bu
rdf:type
rdf:_2
rdf:_3
rdf:type
rdf:_4
rdf:_2
rdf:_1
rdf:_3
rdf:_1
rdf:_2
http://example.org/riverbanks
http://example.org/raodsides
http://example.org/opencountry
http://example.org/Shrews
http://example.org/Mice
http://example.org/Voles
http://example.org/i

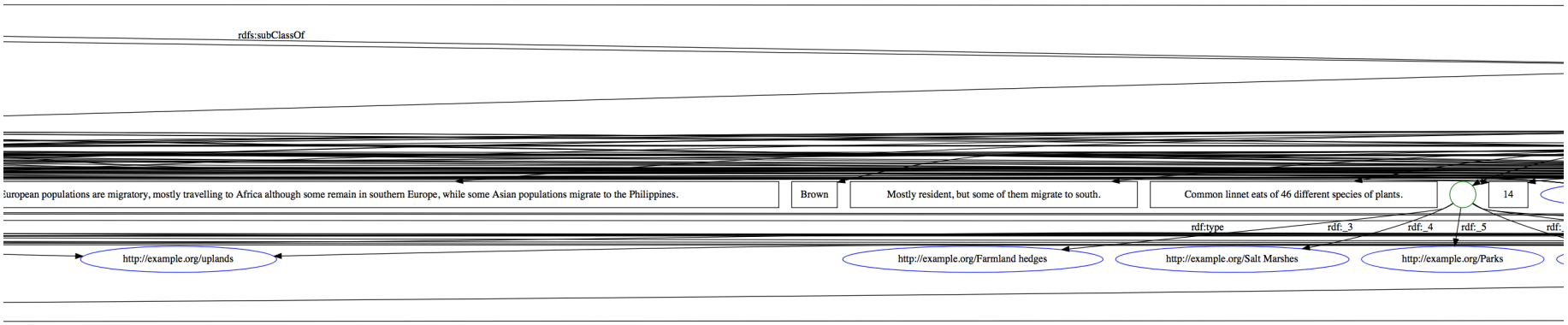

%3
http://example.org/Barn owl
http://example.org/Bullfinch
http://example.org/Lapwing
http://example.org/Merlin
rdf:_3
rdf:type
rdf:_2
rdf:type
rdf:_1
rdf:_3
They are know as northern nightingales.
rdf:Seq
http://example.org/large
http://example.org/short
290
460
Bird of prey
34
15
young Barn owls may disperse but adult Barn owls are nonmigratory
Barn owls have
rdf:type
rdf:type
rdf:_1
rdf:type
rdf:_2
rdf:_2
rdf:_1
http://example.org/Berries
http://example.org/Insects
http://example.org/field edges

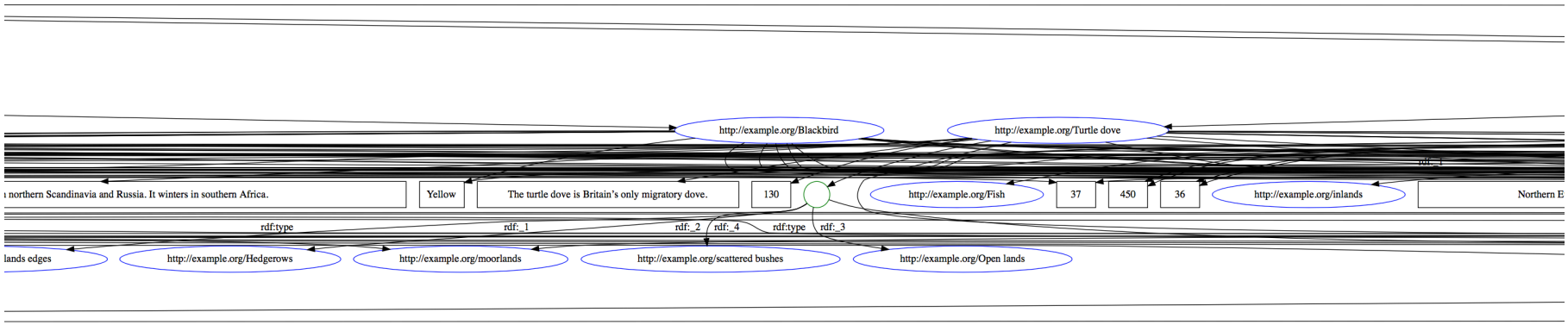

http://example.org/Countryside
:tp://example.org/Blackcap
rdf:type
rdf:_1
Though these birds do not typically migrate, they can be nomadic and may wander with regard to the best food sources throughout the year.
Orange
http://example.org/loud
High
9.4
13
12
16
10
25
In winter, will readily come into gardens.
rdf:_3
rdf:_2
rdf:_1
rdf:_2
rdf:type
rdf:type
rdf:type
http://example.org/seeds
http://example.org/parks
rdf:Bag

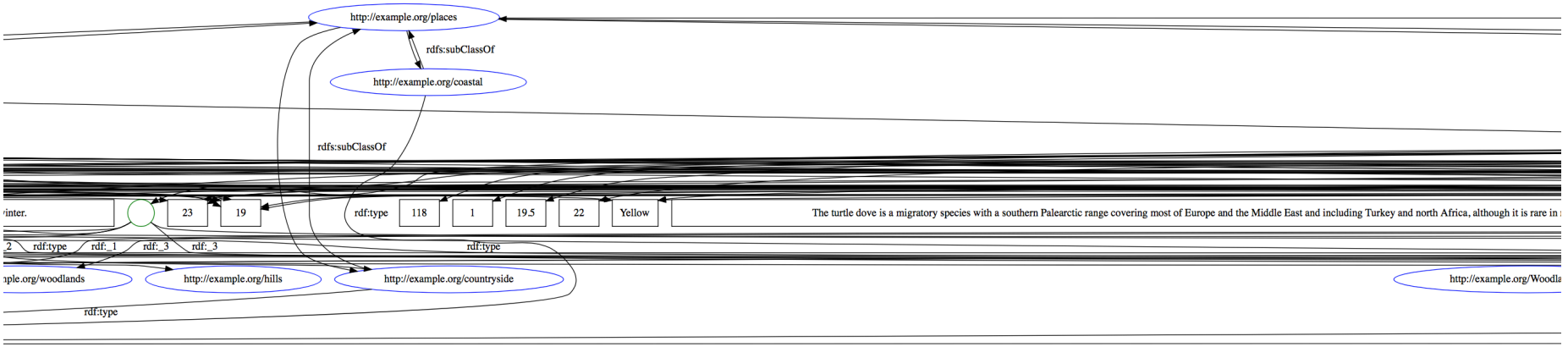

uple.org/Slavonian grebe
http://example.org/Green woodpecker
ht
rdf:_2
21
Red
Red-and-black colour
Low
5
http://example.org/EuropeandwesternAsia
http://example.org/Ants
The pair takes it in turn to incubate the eggs, with the male sitting at night.
8
180
220
rdf:_1
rdf:type
rdf:_2
rdf:_1
rdf:_2
rdf:type
rdf:_1
http://example.org/Coastal uplands
http://example.org/coasts
http://example.org/Marine uplands
http://example.org/aquaticinvertebrates
http://example.org/Smallfish

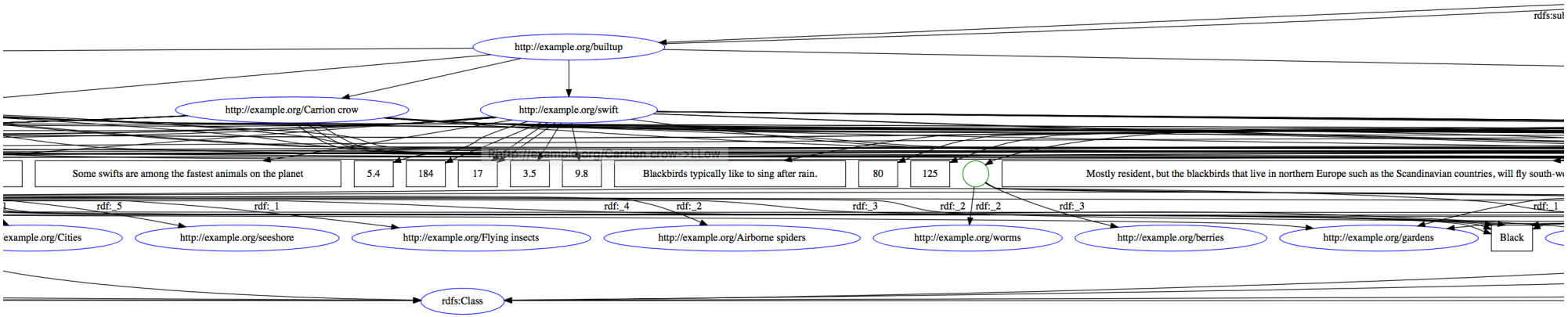

http://example.org/Linnet
http://example.org/
, although in Norway, large concentrations congregate on inland lakes.
http://example.org/median
5.5
White
2
Waterbird
Slavonian grebe eats some of its own feathers so that they can digest fishbone.
Black
true
false
410
21
White

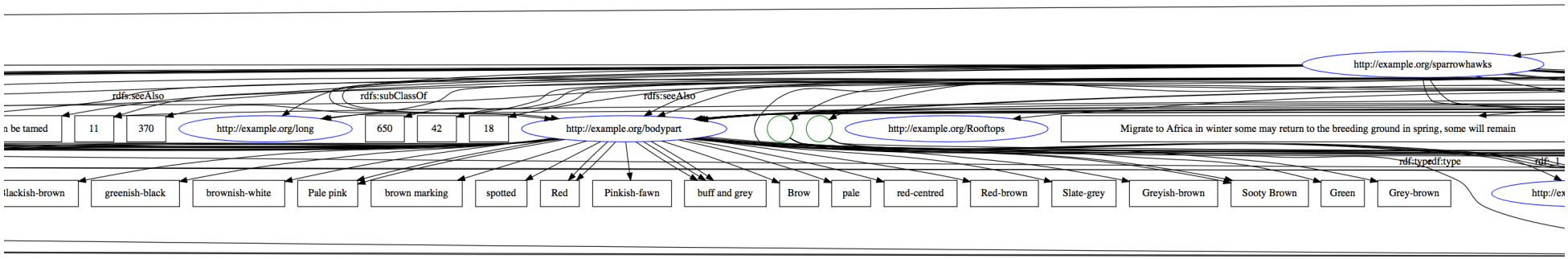

http://example.org/natureresereves
http://example.org/Little egret
rdf:_2
http://example.org/medium
http://example.org/mediumduration
rdf:type
4
Prey
3
During migration, they will stop along lakes, rivers and marshes. Following migration, they winter in marine environments of estuaries and bays or inland on large lakes,
f:_1
rdf:_2
rdf:type
rdf:_1
http://example.org/Heatland
http://example.org/Rough ground
http://example.org/Seeds

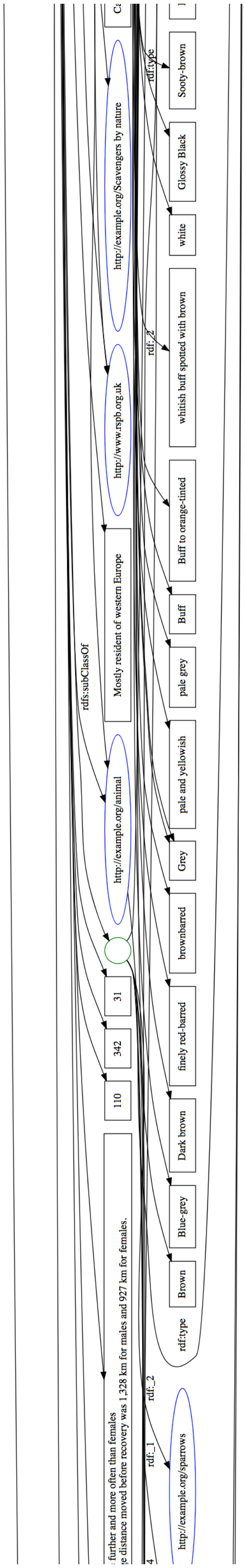

rdfs:subClassOf
European populations are migratory, mostly travelling to Africa although some remain in southern Europe, while some Asian populations migrate to the Philippines.
Brown
Mostly resident, but some of them migrate to south.
Common linnet eats of 46 different species of plants.
14
rdf:type
rdf:_3
rdf:_4
rdf:_5
http://example.org/uplands
http://example.org/Farmland hedges
http://example.org/Salt Marshes
http://example.org/Parks

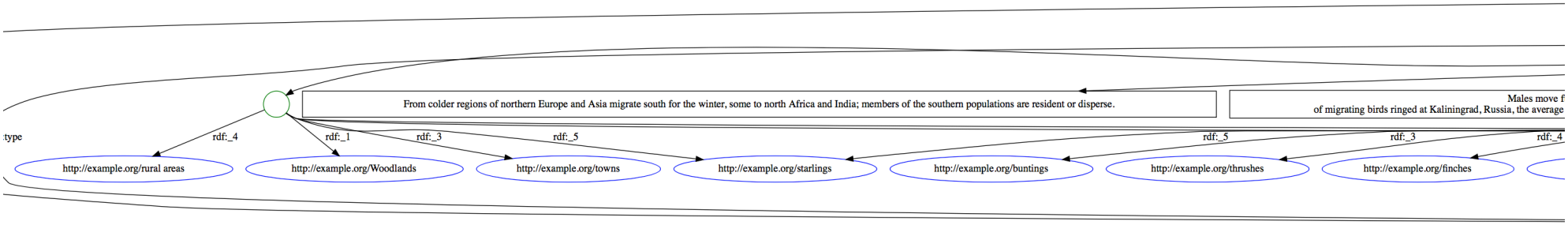

http://example.org/Blackbird
http://example.org/Turtle dove
northern Scandinavia and Russia. It winters in southern Africa.
Yellow
The turtle dove is Britain's only migratory dove.
130
http://example.org/Fish
37
450
36
http://example.org/inlands
Northern E
rdf:type
rdf:_1
rdf:_2
rdf:_4
rdf:type
rdf:_3
lands edges
http://example.org/Hedgerows
http://example.org/moorlands
http://example.org/scattered bushes
http://example.org/Open lands

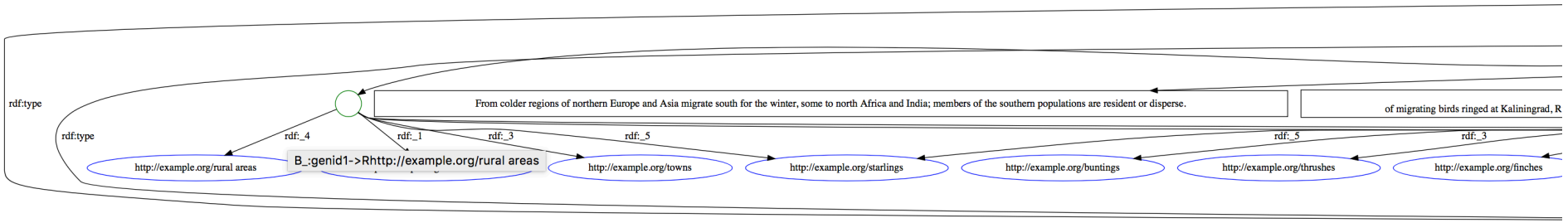

http://example.org/places
rdfs:subClassOf
http://example.org/coastal
rdfs:subClassOf
inter.
23
19
rdf:type
118
1
19.5
22
Yellow
The turtle dove is a migratory species with a southern Palearctic range covering most of Europe and the Middle East and including Turkey and north Africa, although it is rare in
_2
rdf:type
rdf:_1
rdf:_3
rdf:_3
rdf:type
ple.org/woodlands
http://example.org/hills
http://example.org/countryside
http://example.org/Woodla
rdf:type


rdfs:sub
http://example.org/builtup
http://example.org/Carrion crow
http://example.org/swift
Some swifts are among the fastest animals on the planet
5.4
184
17
3.5
9.8
Blackbirds typically like to sing after rain.
80
125
Mostly resident, but the blackbirds that live in northern Europe such as the Scandinavian countries, will fly south-we
rdf:_5
rdf:_1
rdf:_4
rdf:_2
rdf:_3
rdf:_2
rdf:_2
rdf:_3
rdf:_1
example.org/Cities
http://example.org/seeshore
http://example.org/Flying insects
http://example.org/Airborne spiders
http://example.org/worms
http://example.org/berries
http://example.org/gardens
Black
rdfs:Class


http://example.org/sparrowhawks
rdfs:seeAlso
rdfs:subClassOf
rdfs:seeAlso
n be tamed
11
370
http://example.org/long
650
42
18
http://example.org/bodypart
http://example.org/Rooftops
Migrate to Africa in winter some may return to the breeding ground in spring, some will remain
rdf:type
rdf:type
lackish-brown
greenish-black
brownish-white
Pale pink
brown marking
spotted
Red
Pinkish-fawn
buff and grey
Brow
pale
red-centred
Red-brown
Slate-grey
Greyish-brown
Sooty Brown
Green
Grey-brown


http://example.org/Scavengers by nature
http://www.rspb.org.uk
Mostly resident of western Europe
rdfs:subClassOf
http://example.org/animal
31
342
110
further and more often than females
ge distance moved before recovery was 1,328 km for males and 927 km for females.
Sooty-brown
Glossy Black
white
whitish buff spotted with brown
Buff to orange-tinted
Buff
pale grey
pale and yellowish
Grey
brownbarred
finely red-barred
Dark brown
Blue-grey
Brown
rdf:type
rdf:_2
rdf:_1
http://example.org/sparrows


From colder regions of northern Europe and Asia migrate south for the winter, some to north Africa and India; members of the southern populations are resident or disperse.
Males move f
of migrating birds ringed at Kaliningrad, Russia, the average
:type
rdf:_4
rdf:_1
rdf:_3
rdf:_5
rdf:_5
rdf:_3
rdf:_4
http://example.org/rural areas
http://example.org/Woodlands
http://example.org/towns
http://example.org/starlings
http://example.org/buntings
http://example.org/thrushes
http://example.org/finches


rdf:type
rdf:type
rdf:_4
rdf:_1
rdf:_3
rdf:_5
rdf:_5
rdf:_3
From colder regions of northern Europe and Asia migrate south for the winter, some to north Africa and India; members of the southern populations are resident or disperse.
of migrating birds ringed at Kaliningrad, R
http://example.org/rural areas
B_:genid1->Rhttp://example.org/rural areas
http://example.org/towns
http://example.org/starlings
http://example.org/buntings
http://example.org/thrushes
http://example.org/finches

1-4 SPARQL

After creating the semantic data set we can now query the data set using SPARQL.
We are using http://demo.openlinksw.com/sparql for querying and the url for graph is http://sap146.edu.csesalford.com/Semanticwebassignment/Semantic_Web_Rdf_full.xml .
The link is related to the file that we have uploaded through FTP protocol (with file zilla) to University of Salford's servers.
Notice :
Sometimes a namespace could have been used but for demonstration purpose we did not use it.
The output that we are using is HTML for aesthetic purpose. JSON, turtle and many different formats can be used as well.

1-4-1 Query one

```
PREFIX ex: <http://example.org/>
SELECT DISTINCT ?sparrowhawksplaces ?predicatename
WHERE {
<http://example.org/sparrowhawks> ex:naturalhabitat ?sparrowhawkshabitat .
?sparrowhawkshabitat ?predicatename ?sparrowhawksplaces .
}
ORDER by ?sparrowhawksplaces
```

This statement shows places where sparrowhawks usually is seen and provides the relation URI for demonstration purpose and lastly order them by name of sparrow hawks.

sparrowhawksplaces	predicatename
http://demo.openlinksw.com/about/id/entity/http/sap146.edu.csesalford.com/Semanticwebassignment/Semantic_Web_Rdf7.xml	http://www.w3.org/2007/05/powder-s#describedby
http://example.org/Wood lands	http://www.w3.org/1999/02/22-rdf-syntax-ns#_1
http://example.org/gardens	http://www.w3.org/1999/02/22-rdf-syntax-ns#_2
http://example.org/rural areas	http://www.w3.org/1999/02/22-rdf-syntax-ns#_4
http://example.org/starlings	http://www.w3.org/1999/02/22-rdf-syntax-ns#_5
http://example.org/towns	http://www.w3.org/1999/02/22-rdf-syntax-ns#_3
http://www.w3.org/1999/02/22-rdf-syntax-ns#Bag	http://www.w3.org/1999/02/22-rdf-syntax-ns#type

Figure 1-1 Query one

1-4-2 Query two

```
PREFIX ex: <http://example.org/>
SELECT  ?maxwingspan ?nameofbird ?upperpartcolour
WHERE {
?nameofbird ex:maxwingspan ?maxwingspan .

OPTIONAL{
?nameofbird ex:colour ?bodypart .
?bodypart ex:upperpartcolour ?upperpartcolour .
}
}
ORDER by DESC(?maxwingspan) LIMIT 1
```

This statement is selecting the the bird with maximum wingspan and its name and if the body part of this bird has different color than the rest of the body it selects its colour as well but if the bird had single value for its colour the result would be empty but optional keyword indicates that the triplet is not mandatory for the result set but if it exists, it will emerge.
Then the result will be ordered in descending order and then the first value of this list will be shown. With this way by going through maxwingspan attributes and ordering them and showing the first value in the list we will have the largest wingspan.

maxwingspan	nameofbird	upperpartcolour
42	http://example.org/Carrion crow	"Black"

Figure 1-2 Query two

1-4-3 Query three

```
PREFIX ex: <http://example.org/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT ?nameofbird ?Foodname ?loudness
WHERE {
?nameofbird ex:nocturnal "false"^^xsd:boolean ;
ex:regularpattern "false"^^xsd:boolean ;
ex:minlifespan ?minlifespan .
OPTIONAL {
?nameofbird ex:typicalfood ?BAG ;
ex:loudness ?loudness .
?BAG ?has ?Foodname .
}
FILTER (?minlifespan > "2"^^xsd:integer)
}
ORDER BY (?nameofbird)
```

The third query selects non repetitive values of bird's name and their foods and the loudness of their voice while using different sorts of filters.
First the birds should be active in daylight(not nocturnal) and the datatype needs to be specified since in the XML/RDF Serialisation we have specified the datatype of nocturnal attribute to boolean. Another filter is that the bird should not have regular voice and they way it is serialised is like the previous one.
It should have more than 2 years of life span (with specified datatype of integer) and if it has multiple typical food it will be outputted as well.
The end result would be like this :

nameofbird	Foodname	loudness
http://example.org/Blackbird	http://example.org/berries	http://example.org/medium
http://example.org/Blackbird	http://www.w3.org/1999/02/22-rdf-syntax-ns#Bag	http://example.org/medium
http://example.org/Blackbird	http://example.org/worms	http://example.org/medium
http://example.org/Blackbird	http://example.org/Insects	http://example.org/medium
http://example.org/Blackbird	http://demo.openlinksw.com/about/id/entity/http/sap146.edu.csesalford.com/Semanticwebassignment/Semantic_Web_Rdf_full.xml	http://example.org/medium
http://example.org/Kingfisher	http://example.org/fish	http://example.org/medium
http://example.org/Kingfisher	http://demo.openlinksw.com/about/id/entity/http/sap146.edu.csesalford.com/Semanticwebassignment/Semantic_Web_Rdf_full.xml	http://example.org/medium
http://example.org/Kingfisher	http://www.w3.org/1999/02/22-rdf-syntax-ns#Bag	http://example.org/medium
http://example.org/Kingfisher	http://example.org/Aquatic insects	http://example.org/medium

Figure 1-3 Query three

1-4-4 Query four

```
PREFIX ex: <http://example.org/>
PREFIX sch: <http://www.w3.org/2000/01/rdf-schema#>
SELECT ?nameofbird ?birdsize ?interestingfact ?pitch ?regularity ?duration
WHERE {
<http://example.org/builtup> a sch:Class ;
ex:nameofbird ?nameofbird .
?nameofbird ex:size ?birdsize ;
ex:interestingfact ?interestingfact ;
ex:pitch ?pitch ;
ex:regularpattern ?regularity ;
ex:duration ?duration ;
}
ORDER by DESC(?birdsize) LIMIT 1
```

This query selects biggest bird and shows its name, size, and the pitch and regularity pattern and duration of its voice and an interesting fact only if the type of builtup be Class.

nameofbird	birdsize	interestingfact
http://example.org/swift	http://example.org/small	"Some swifts are among the fastest animals on the planet "

pitch	regularity	duration
"High"	"true"^^<http://www.w3.org/2001/XMLSchema#boolean>	http://example.org/mediumduration

Figure 1-4 Query Four

1-4-5 Query five

```
PREFIX ex: <http://example.org/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT ?nameofbird ?terminologicalknowledge ?type ?interestingfact
WHERE {
?Place ex:nameofbird ?nameofbird .
?nameofbird ex:eyecolour ?eyecolour ;
ex:regularpattern "true"^^xsd:boolean ;
ex:type ?type ;
ex:interestingfact ?interestingfact
OPTIONAL { ?nameofbird a ?terminologicalknowledge .}
FILTER ( REGEX(?eyecolour, "^Dark") )
}
```

This query selects the name of bird and what its terminological dependency and shows whether it is prey and an interesting fact about the bird when these criteria meet :

- The data of eye colour for bird does exist
- The colour should be in dark spectrum
- The bird's sound should be regular
- If the bird belongs to a class, it will be selected but it is not mandatory to have a class.

nameofbird	terminologicalknowledge	type	interestingfact
http://example.org/swift	http://www.w3.org/2000/01/rdf-schema#Class	"Prey"	"Some swifts are among the fastest animals on the planet "
http://example.org/Meadow pipit		"Prey"	"Have short song for short flight "
http://example.org/Bullfinch		"Prey"	"They form strong, lasting pair bounds and it is usual to see them in pairs throughout the year "

Figure 1-5 Query Five

Music recommendation from audio data

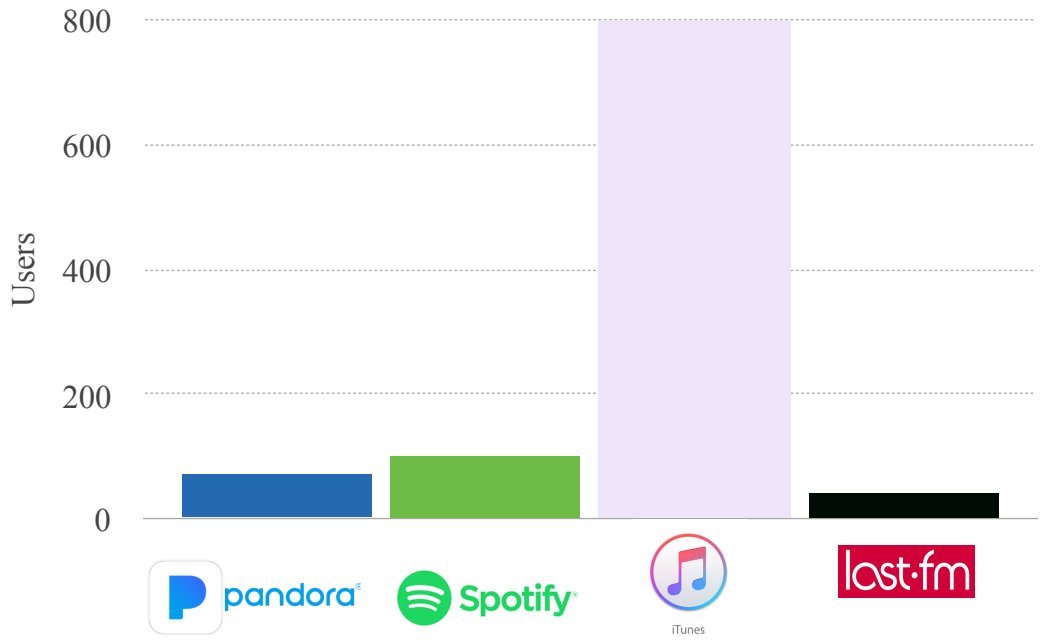
Abstract

Music recommendation systems have used different approaches but the one that has been used widely is Collaborative filtering approach. While the last result of the recommended songs by this approach is highly accurate there are some fundamental challenges to it.for example in Collaborate Filtering new unpopular songs which have not been purchased by any users can not be recommended or popular songs are more likely to be recommended to anyone.There are other approaches like content-base filtering which overcome these issue by assigning certain tags to songs and storing these tags into database but the main challenge with this method is time and scalability due to the face that each song should be manually annotated by humans and then there are auto tagging approaches that tackle this issue but does not support linear order of songs due to their nature.Lastly the Hybrid method exploits both approach for better result by combining distances in mentioned approaches. In this paper I will discussed briefly how these approaches implemented and what are the pros and cons of these approaches.

Keywords
Information extraction, audio extraction, music recommendation algorithms, content-based filtering, collaborative filtering , audio tags,

Introduction

Assessing similarities between items, plays a vital roles in many scenarios on the internet these days from e-commerce websites to streaming websites like Netflix. Most of us have seen the recommended items in Amazon's checkout page or Netflix recommendations and while sometimes they are accurate, there are times that these recommendations are completely off-topic and inaccurate.
In this article I am focusing on music recommendations and discuss different approaches and pros and cons of these approaches that are used in music streaming companies for suggesting new song for a user finding his or her taste of music implicitly or explicitly.



When it comes to music recommendation there are certain aspects that should be covered. Beside the accuracy of suggestion which is the main challenge for obvious reason, the time that the service is delivered to user is crucial because the user will not use the service if it passes certain amount of time to suggest a song.

2-1 Content-base Filtering (Audio tagging)

This approach provides tag associated with a song and this can be embedded either by humans or automatically.When tags are embedded by humans, tags can be extracted in more implicit way such as developing a genre-guessing game or using social media as a reliable source; For example, Pandora Inc. has hired musicians to listen to the songs and manually associate them with certain tags.
Companies that use audio tagging are relying on proximity measure algorithms to determine the neighborhood of songs and techniques to cluster songs that are neighborhood.The way it has been implemented is that it associates an station's preferences a single value and associated a value to each song in the database and the last step is comparing these two value.

There are some challenges with audio tagging. first, it should be evaluated by humans at the end. It is easy to associate a song with a tag but it is more complicated is to tell whether a tag should not be applied to the song; maybe a tag is more closer to a song and one tag totally unrelated to a song and in this case human role is crucial.
The other challenge to this method is time and time-consuming services are user-prohibitive. The algorithms in audio tagging occurs in polynomial time. Crucial part of time is the time it takes to choose the next song.this can be done in O(mn) where m is number of songs in the

current station and n is number of attributes that characterise a song, to create the value for station and fixed time to query the database for the closest matches to this value.
The main problem with this approach is scalability.The database of the songs is limited and lesser known songs will not be discovered if they are not considered as worthy by company. A possible solution for this is to combine this approach with the second approach where the people collaborating in clustering the songs how can we trust users? possible way to tackle this issue is to compare the ratings of users with those of the employees and if they have certain similarity, these users are qualified as contributor and mixing this approach with tracking thumbs up can leads to even better result since it can eliminate some inappropriate tagging.
Another way of annotating a song with certain tags is using auto tags. This approach divides a song into 50 to 200 milliseconds snippets and then use Mel-frequency cepstral coefficient (MFCC) to from a "feature space" (cloud of dots) based on these snippets. MFCC uses Fourier transform (FT) of the spectrum of an audio clip. After performing this process for different songs, it derives certain model(shape of cloud of dots) for each genre regardless of the order of snippets(Gaussian mixture models) which is not modeling temporal phenomena.This approach allows a rich vocabulary which contains certain "acoustic pattern" that can be used to recommend a song that has never heard before.
For adding new song it just chop it into snippets of 50 ms and from cloud of dots with MFCC then compare these dots with the created models and pick model that describe the song best. (the distance ∂ is calculated and those closest to the model are determine the model).
The main challenges with this approach are temporal modeling and the length of snippets because if it is too long, the signal become non-stationary over the very long time frame and does not pick the very specific detail of waveform anymore and if it is too short, there is a chance of extracting noise.

2-2 Collaborative Filtering

Collaborative filtering is a recommendation strategy that looks at how the items in a store for example iTunes have been used by a massive amount of users. This approach creates a graph based on the items that users have bought and then tries to cluster them into a group and then

based on these groups recommend the next song. So for example in the diagram below if a new user play item A based on other people records, item B will be suggested.

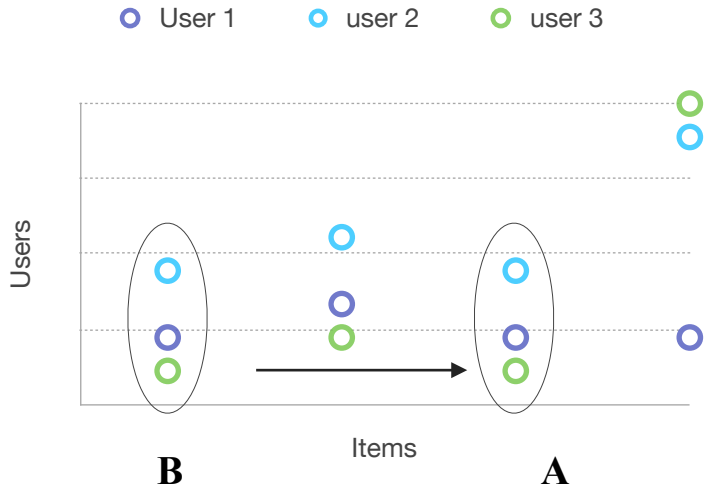
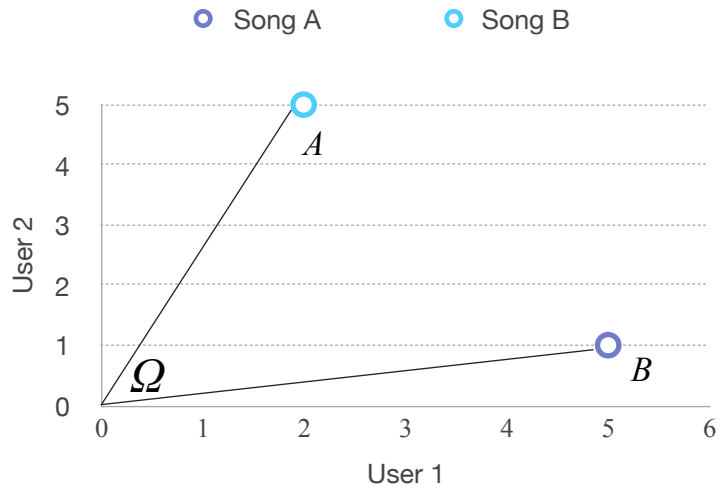


Figure 2.1 content-base recommendation

Collaborative filtering can add prediction to its recommendation mechanism for better functionality. This can be done explicitly when user express his/her opinion by a rating system or implicitly by analyzing timing log of purchase records or mining web hyperlinks.There are two main algorithms in this field. Memory-based Collaborative Filtering Algorithms and Model-based Collaborative Filtering Algorithms.

In memory-based collaborative filtering the systems forms what is referred as “Neighbors”. Neighbors are derived from statistical techniques and they are the users that have agreeing history with the target user. This can be me achieved by what is called as “similarity metric”.



Figur 2.2 Similarity Diagram

Similarity metric can be used between users or songs and the above diagram indicates similarity diagram between 2 songs. First, user 1 gives 5 star to song A and 2 star to song B and user 2 gives 1 star to song A and 5 star to song B so this two song are very different due to major difference between the two users' ratings.

The way this works is that d=COS(Ω) is calculated and then the absolute value of d determines whether two song are very similar or very dissimilar (if *d* is negative). In thousand of songs between two users top 10 absolute value of cos coefficient (d) can tell which 10 song are more similar to each other. These top value items of |d| are constitute what is know as neighbors.

Neighboring is used by other recommendation companies as well for example Netflix and Last FM are using neighboring for their recommendation service. The second algorithm is model-based algorithm which uses probabilistic approach to predict the recommended song.This approach uses machine learning approaches such as clustering, and rule-based approaches. Clustering approach is tries to form clusters by estimating that a particular user falls into a certain cluster. The rule-based approach uses association rule discovery algorithms and finds association between co-purchased items and then tries to recommend an item based on these associations.

These approaches automated the processes of importing data into database and in most of the time works accurately but these approaches have two major problems.

First, the song should be played at least by a user which is commonly referred as "cold-start" . As it can be seen in the following graph there is no chance that the system recommend a song that has not been purchased.These items referred as empty columns and there is no way to access this column in this approach.

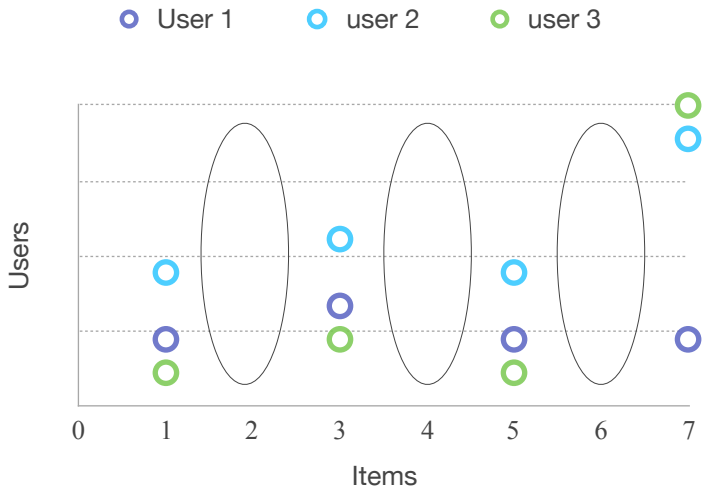


Figure 2.4 Empty columns

Imagine you are uploading your new song and there is no chance that this song is recommended by the system. (Item 2,4,6 in the diagram). Another problem is that when a

song is popular from the beginning it will become even more popular because it has purchased by many people.Spotify and iTunes used to use this approach but due to its problems in finding new song they combined it with other approaches and algorithms.
In hybrid approach both content-based filtering and collaborative filtering combined together. Hybrid weight (ß) is derived from d value from collaborative filtering and Mahalanobis ∂ which is extracted based of MFCC from each song in content-base filtering. Since these two metrics are rather different from each other, they need to be normalized and then they constitute ß and in this way the problem of cold start will be solved.

References

Howe, M. (2007) *Pandora's Music Recommender*. [pdf] Washington: University of Washington. Available at https://courses.cs.washington.edu/courses/csep521/07wi/prj/michael.pdf [Online; accessed April 2017].

Sarwar, B., Karypis, G., Konstan J., Riedl J. (2001) *Item-based Collaborative Filtering Recommendation Algorithms.* [pdf] Minnesota: University of Minnesota, Minneapolis. Available at http://delivery.acm.org/10.1145/380000/372071/p285-sarwar.pdf?ip=146.87.136.67&id=372071&acc=ACTIVE%20SERVICE&key=BF07A2EE685417C5%2E6B3F7B241F273757%2E4D4702B0C3E38B35%2E4D4702B0C3E38B35&CFID=755464973&CFTOKEN=93614103&__acm__=1493216379_4e6a618baa5852d9cc6d3cabcf905e2c [Online; accessed April 2017]

Kaufman, J. (2014) *A Hybrid Approach to Music Recommendation: Exploiting Collaborative Music Tags and Acoustic Features.* [pdf] Florida: University of North Florida. Available at http://digitalcommons.unf.edu/cgi/viewcontent.cgi?article=1576&context=etd [Online; accessed April 2017]

BertinMahieux, T., Eck, D., Mandel, M. (2011) *Automatic Tagging of Audio: The State-of-the-Art.* [pdf] Montreal: University of Montreal. Available at http://tbertinmahieux.com/Papers/machineaudition10.pdf [Online; accessed April 2017]

The spruce. Available at: www.thespruce.com, (Accessed: April 2017).
British Garden Birds. Available at: www.garden-birds.co.uk, (Accessed: April 2017).
The Royal Society for the Protection of Birds. Available at: www.rspb.org.uk, (Accessed: April 2017).
Living with birds. Available at: www.livingwithbirds.com (Accessed: April 2017).
The Wildlife Trusts. Available at: www.wildlifetrusts.org, (Accessed: April 2017).
University of Wisconsin System. Available at: http://bioweb.uwlax.edu, (Accessed: April 2017).
The Cornell Lab of Ornithology. Available at: www.allaboutbirds.org, (Accessed: April 2017).
Carruthers, L. (2006). *The Animal Files*. Available at: www.theanimalfiles.com, (Accessed: April 2017).
soft schools. Available at: www.softschools.com, (Accessed: April 2017).
Whatbird. Available at: www.whatbird.com, (Accessed: April 2017).
Birds in Cheshire and Wirral, A breeding and wintering atlas. Available at: www.cheshireandwirralbirdatlas.org, (Accessed: April 2017).
www.twootz.com, (Accessed: April 2017).
uk safari. Available at: www.uksafari.com, (Accessed: April 2017).