NORTHWEST NAZARENE UNIVERSITY

Assisting Frog Identification in Costa Rica Using a Mobile App

THESIS
Submitted to the Department of Mathematics and Computer Science
in partial fulfillment of the requirements
for the degree of
BACHELOR OF ARTS

Justin Tyler Laplante
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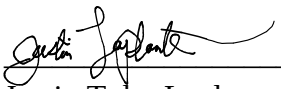
Author: 
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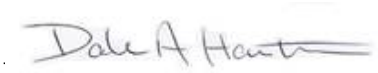
Approved: 
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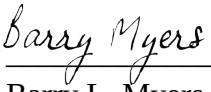
Approved: 
Barry L. Myers, Ph.D., Chair, Department of Mathematics & Computer Science

ABSTRACT

Assisting Frog Identification in Costa Rica Using a Mobile App.
LAPLANTE, JUSTIN (Department of Mathematics and Computer Science).

Quickly identifying a single frog species from over a hundred other possible species can be a challenge for research while in the Costa Rican jungle. Though researchers can use field guides to assist, these still mean you may have look through all currently identified frog species to find the frog being viewed. This project was created to help researchers narrow the list of possible frog species quickly based on Geolocation. Using Xamarin.Forms, an app was developed that worked offline, used an ArcGIS API and was cross platform. However, to ensure performs and accuracy certain design choices were made for designing the ArcGIS map that was used within the app. The used geospatial data for the frog species and generalized it into a hexagonal pattern. For the app to handle the frog and app data using xml and the MVVM Architectural pattern.

Acknowledgement

I would like to thank my parents for giving me the wonderful opportunity of going to college. I would like to thank Dr. Myers, Dr. Hamilton, and Prof. McCarty for being excellent professors in all the computer science classes and teaching me more than I know what to do with. I would like to thank Dr. Cossel for giving me a senior project that I really enjoyed working on and showed me how much I have yet to learn. Finally, I want to thank my first three years of excellent roommates in college, I never knew how lucky I was to have each one of them until senior year when I didn't have them.

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Project Overview:

This project used Xamarin forms, a .NET framework extension, to build a cross-platform friendly mobile app that can be used on android and IOS to assist researchers in Costa Rica in identifying frogs quicker using an interactive ArcGIS map within the application.

Application Requirements:

When designing and coming up with the applications, it needed to accomplish four main things:

1. The application needed to narrow down a list of frogs using the application device's built-in geolocation against an ArcGIS map.
2. The user needed to be able to look at and view each frog both in the narrower list and in general to enable the user to visually see what the selected frog species looks like and receive written information on the frog.
3. It needed to work on Android and IOS with usability on tablet and phone screen size in mind.
4. The application also needs to be able to be used offline and in the field.

Design Choices:

Designing Application:

At the beginning of the project, a straightforward design was ideal. The design would allow the user to see the ArcGIS map displayed over Costa Rica. Then let the user click a button to show them all the frogs within the area. Ending with them clicking on the frog, they believe it is to see more information on that frog. To storyboard the

application and run the design past Dr. Cossel, Adobe XD was used. XD allowed for quick prototyping of the application without needing to code anything. Giving a clear design path to build towards for the application.

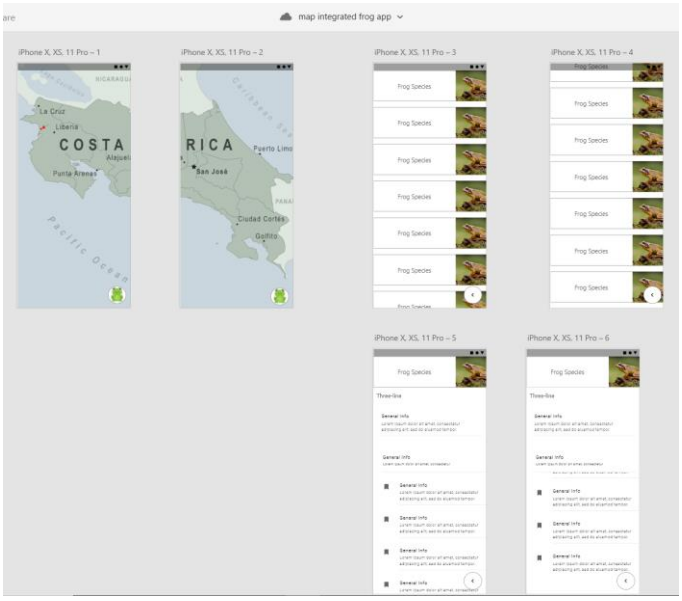

Figure 1. Adobe XD storyboard

Application Development Framework:

When deciding what framework to develop the application in, there were two desired features. First, that it would allow for cross-platform development. Second, that it could effectively use and interact with ArcGIS maps. When choosing between the different cross-platform frameworks, most are based on JavaScript, such as React Native, NativeScript or PhoneGap. JavaScript is problematic when working with ArcGIS because the ArcGIS SDK for JavaScript cannot take ArcGIS maps offline in Mobile Map Packages (MMPK), which is the only way to use them offline. So Xamarin ended up being the framework used for development because it's built on the .NET framework. On top of developing cross-platform applications, it also allowed the use of ArcGIS SDK for .NET, which enables applications to use MMPK.

Application Data Design Pattern:

With the framework chosen, it was time to develop the application. A major decision that had to be made for this step was how to handle data movement behind the scenes between pages. There were a few different patterns that were considered, Model-View-Controller (MVC), Model-View-Presenter (MVP), Model-View-ViewModel (MVVM). All of these have three key similarities:

1. The “Model” in each of these primarily refers to where data for the application is held.
2. The “View” in each refers broadly to the UI where the user will see data held in the model.
3. Though the name changes the C, P, and VM, all represent how the view and model interact in one way or another. But This interaction is where these models differ.

For MVC, when an event occurs, it goes through the control, and if needed, the control will update the data within the model. The model then tells the view when its data changes, and the view gets that new data and updates the UI. However, this means the business logic and the UI intermingle, so to test the application, all features need to be working before debugging can occur. So, for work to be done on UI in future work, the developer would need to have a good grasp on how all the behind-the-scenes logic works, making it harder for future people to work on it and update the application (Hanmer, 2013; Maxwell, 2017).

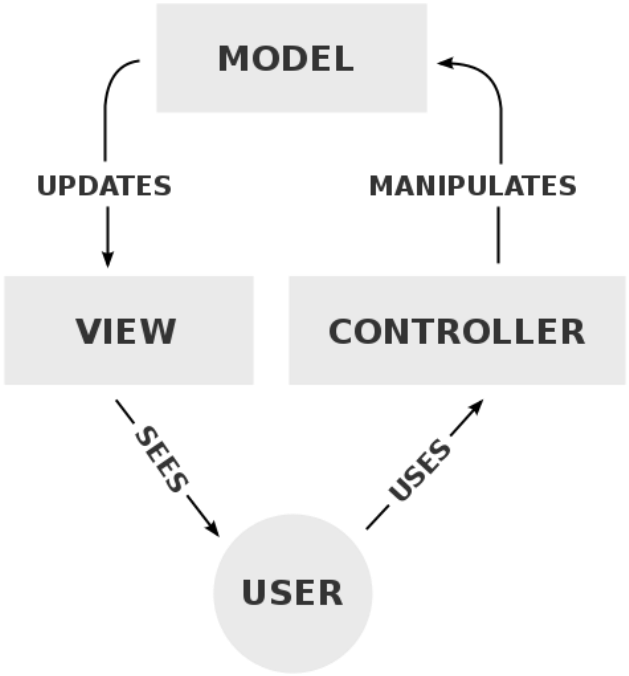

Figure 2. MVC Process (Frey, 2010)

For MVP, the view never interacts directly with the model. Instead, the view lets the presenter know when the user acts, then the presenter either tells the view how to change or tells the model what data needs changing, and then the model informs the up the chain what data was changed and the UI updates. The most important point about this model is that the view and the presenter are a one-to-one relationship meaning they rely on and interact with each other. This one-to-one relationship is a problem because it still means that the UI is tied to the business logic, and any work done on it would require knowledge outside of designing the UI (Maxwell, 2017; Mishra, 2020).

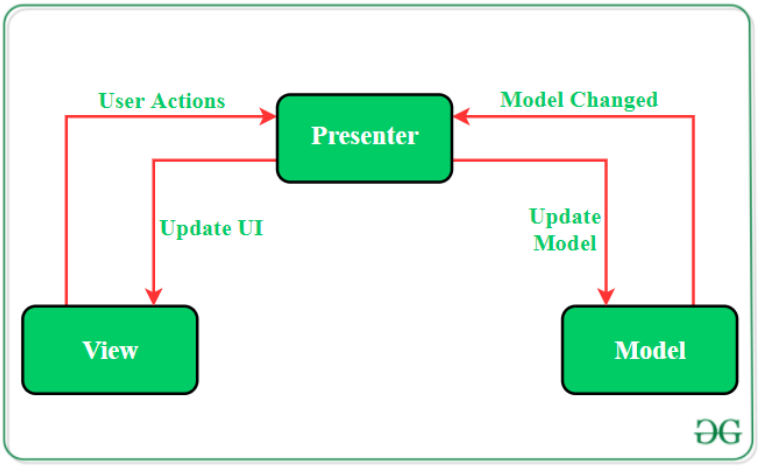

Figure 3. MVP Process (Mishra, 2020)

Finally, for MVVM, the view only contains logic related to the UI, such as animation. The view only gets data from the model through the ViewModel, similar to the presenter in MVP. However, the difference lies in that all business logic and data from the model stay in the ViewModel connected to the UI through data binding, essentially just referencing the data and events and linking it to the UI. (picture of code using data binding). This data binding is important because it enables the view to be disconnected from the ViewModel and model and manipulated and tweaked. So long as the name used in the binding is a public variable within the ViewModel, they can functionally separate. This separation means that the ViewModel can run entirely by itself and be tested without the need for a view (Britch et al., 2017; Maxwell, 2017).

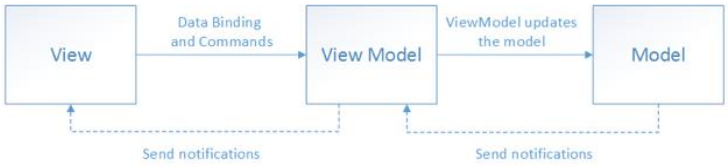

Figure 4. MVVM Process (Britch et al., 2017)

Since the MVVM pattern gave the application the ability to be worked on with both the logic and the UI separately for future work, the application was designed with the MVVM pattern in mind.

Designing a custom ArcGIS Map:

For this application, the user needed to be able to click on an ArcGIS map and see what frogs were in that area or use their GPS Coordinates to see frogs within their area. To do this and simplify the amount of loading and processing the device with the application would need to do, a custom map was designed for the application. To accomplish this, a hexagon overlay that used 10km hexagons, each one containing all frog species within that area, over all of Costa Rica. Using a hexagon pattern instead of the true regions meant the device would not need to handle millions of points that make up the edge of those shapes. The 10km size optimized the accuracy of possible frogs.

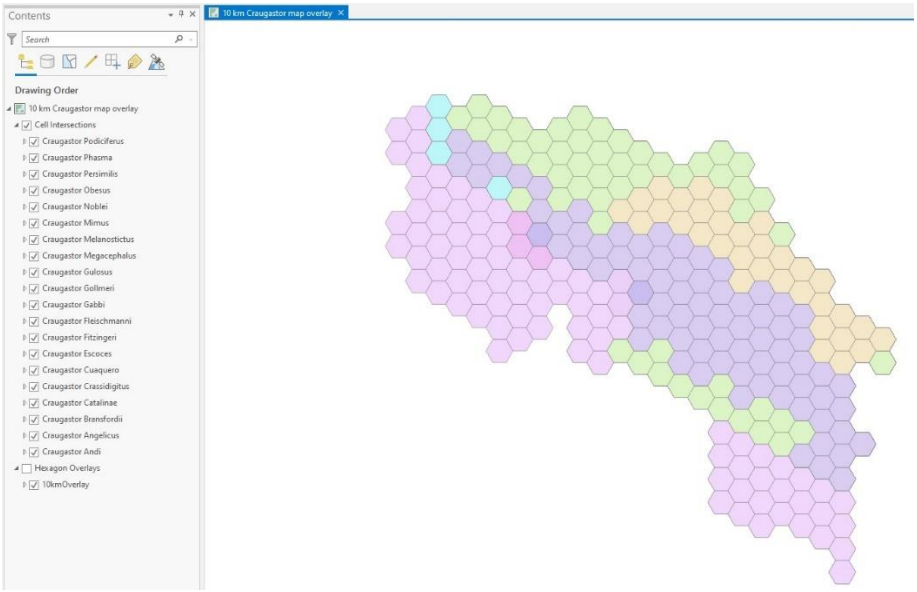

Figure 5. Custom ArcGIS Map

Development:

Application Views:

The application consists of 4 main views: MMPK selection, Map View, List of Frogs, Frog Details. The MMPK selection view welcomes the user to the app and has a button to select the MMPK that they will use to identify frogs. The idea behind this view is so that the app could potentially be used for either more precise MMPK's or in other regions, allowing the app to have expansive possibilities.

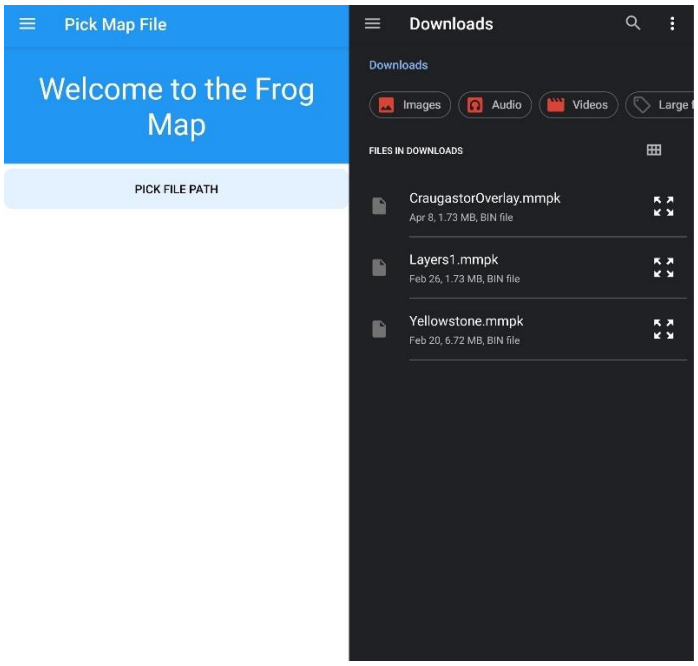

Figure 6. MMPK Selection View

Whichever MMPK is loaded is displayed within the map view. This view displays the ArcGIS layers that are visible within the MMPK and gives the user the ability to click on the map. Supposing the MMPK the user loaded is the custom MMPK created for this application when the user taps on a hexagon. Then they are greeted with a message that lets them quickly know the frog species in the area they clicked, the number of hexagons they tapped on that had that frog species, and how many hexagons they clicked on.

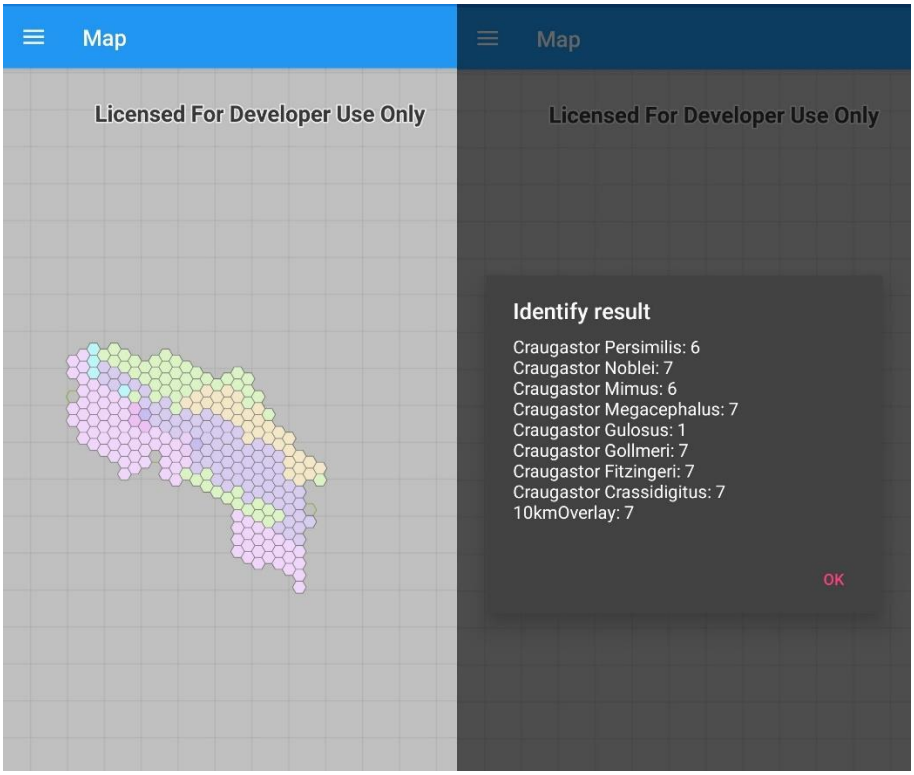

Figure 7. Map View

If the user wants to view this lister closer, they can hit ok and are taken to the list of local frogs that were present on the Identified Results message. On this list, you see the species Latin name with their common name just underneath it.

Figure 8. List of Frogs View

Each species is present like a button and can be clicked on to take the user to the frog's detail View. This view displays details on the frog, including their description, similar species, calls, and Range and Habitat.

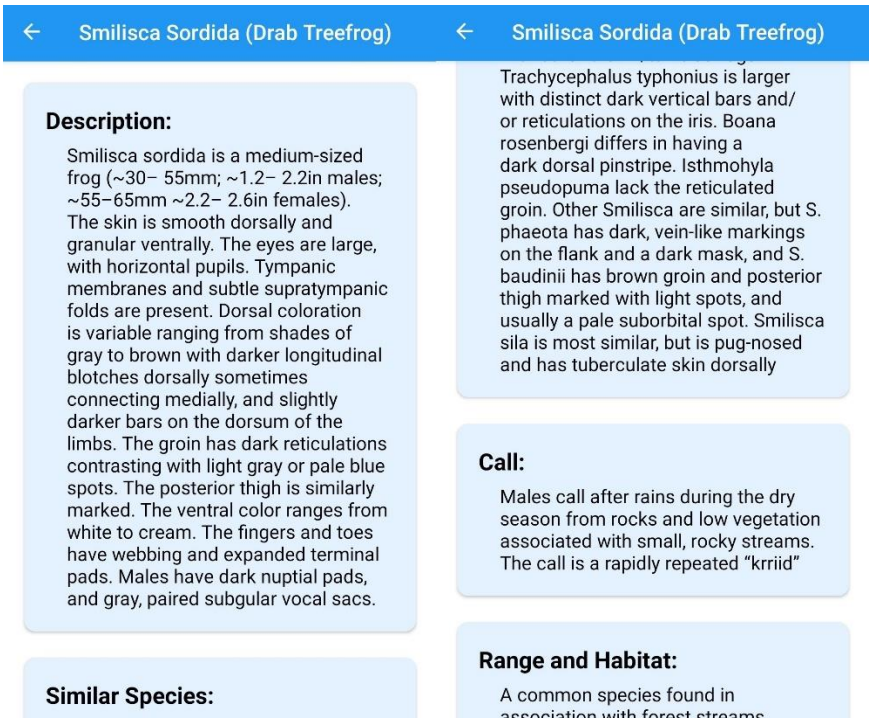

Figure 9. Frog Detail View

Final Remarks

Complications:

There were a few issues that were encountered during the development of this project. First, when allocating the ArcGIS map design to a group's final assignment, somewhere during the final stages of putting the map together, the Map's Coordinate system was corrupted. The corrupted coordinates meant that even though all the hexagons remained together when overlayed with a base layer map, they do not sit over Costa Rica. This is problematic because it means that GPS can not be used within the application to find your current location and tell you local frogs within your hexagon.

The other issue was that Xamarin is being deprecated in a few years by Microsoft in favor of their new .NET Multi-platform App UI they are developing. This depreciation means that though the app still could function for a while, it is already running a shorter life cycle. Thankfully, MAUI is being built using many Xamarin features and is more like a clean evolution of Xamarin, so it could be easily ported over once MAUI is released and operational.

Future Work:

The Application is close to being fully functional; however, there are three things that it needs to be done before this can be true:

1. The custom ArcGIS map needs to be complete both with all of the frog species in it as well as fixing the coordinate system that they are all projected onto so that it can be used on a base layer that actually gives the surrounding details of Costa Rica and flushes out the Map View.
2. Once the ArcGIS map is done, the Map View needs GPS coordinates to be implemented into the ViewModel so that the user can also use that to access what local frogs are in their area, making it usable within the field.
3. It needs pictures to be added to the local frogs view next to each frog species and on the frog description page to help researchers more quickly identify the frog species they may be looking at.

Conclusion:

This project has helped show me how similar goals on different development tools can change how the development goes dramatically. For an internship, I had to do a similar task with ArcGIS but for a website online. Switching it to .NET and offline meant

that I had to start over from scratch in how I had to approach the problem, and it meant that I only had better knowledge of terms. This project also taught me the importance of having a healthy “home” life on the productivity of a large-scale project like this. Ultimately what this project taught me is that no matter how hard a task is and no matter how much life drags you down, the point is not whether you came first or last but that you finished.

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Appendix A: Models

FrogSpecies.cs

```
namespace XamarinFormsFromScratch.Models
{
    public class FrogSpecies
    {
        public string SpeciesLatin { get; set; }
        public string SpeciesEnglish { get; set; }
        public string Description { get; set; }
        public string SimilarSpecies { get; set; }
        public string Calls { get; set; }
        public string RangeAndHabitat { get; set; }
        public string PageNumber { get; set; }
    }
}
```

Appendix B: Services

FrogSpeciesDataStore.cs

```
using System.Collections.Generic;
using System.Linq;
using System.Threading.Tasks;
using XamarinFormsFromScratch.Models;
using System.Xml.Serialization;
using System.IO;
using System.Reflection;

namespace XamarinFormsFromScratch.Services
{
   class FrogSpeciesDataStore : ISpeciesButtonStorage<FrogSpecies>
   {
      readonly List<FrogSpecies> frogs;//creates a list for the FrogSpecies groups

      public FrogSpeciesDataStore()
      {

         var assembly = IntrospectionExtensions.GetTypeInfo(typeof(FrogSpeciesDataStore)).Assembly;
         Stream stream =
assembly.GetManifestResourceStream("XamarinFormsFromScratch.FrogSpeciesInfo.FrogSpeciesInfoXM
L.xml");
         using (var reader = new System.IO.StreamReader(stream))
         {
            var serializer = new XmlSerializer(typeof(List<FrogSpecies>));
            frogs = (List<FrogSpecies>)serializer.Deserialize(reader);
         }
      }

      public async Task<bool> AddFrogAsync(FrogSpecies frogSpecies)
      {
         frogs.Add(frogSpecies);

         return await Task.FromResult(true);
      }

      public async Task<bool> UpdateFrogAsync(FrogSpecies frogSpecies)
      {
         var oldFrog = frogs.Where((FrogSpecies arg) => arg.SpeciesLatin ==
frogSpecies.SpeciesLatin).FirstOrDefault();
         frogs.Remove(oldFrog);
         frogs.Add(frogSpecies);

         return await Task.FromResult(true);
      }

      //get frog, get frogs, get set of frogs
      public async Task<FrogSpecies> GetFrogAsync(string speciesLatin)
      {
         return await Task.FromResult(frogs.FirstOrDefault(s => s.SpeciesLatin == speciesLatin));
      }
```

```
        public async Task<IEnumerable<FrogSpecies>> GetFrogAsync(bool forceRefresh = false)
        {
            return await Task.FromResult(frogs);
        }
    }
}
```

ISpeciesButtonStorage.cs

```
using System.Collections.Generic;
using System.Threading.Tasks;

namespace XamarinFormsFromScratch.Services
{
    public interface ISpeciesButtonStorage<T>
    {
        Task<bool> AddFrogAsync(T frogSpecies);
        Task<bool> UpdateFrogAsync(T frogSpecies);
        Task<T> GetFrogAsync(string id);
        Task<IEnumerable<T>> GetFrogAsync(bool forcerefresh = false);
    }
}
```

Appendix C: ViewModel

BaseViewModel.cs

```
using XamarinFormsFromScratch.Models;
using XamarinFormsFromScratch.Services;
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Runtime.CompilerServices;
using Xamarin.Forms;

namespace XamarinFormsFromScratch.ViewModel
{
   //base viewmodel class
   //allows us to make changes to this classes if something needs to apply to all of them
   public class BaseViewModel : INotifyPropertyChanged
   {

      public ISpeciesButtonStorage<FrogSpecies> FrogStore =>
DependencyService.Get<ISpeciesButtonStorage<FrogSpecies>>();

      bool isBusy = false;
      public bool IsBusy
      {
         get { return isBusy; }
         set { SetProperty(ref isBusy, value); }
      }

      //This is the variable that will display at the top of each page
      string title = string.Empty;
      public string Title
      {
         get { return title; }
         set { SetProperty(ref title, value); }
      }


      protected bool SetProperty<T>(ref T backingStore, T value,
         [CallerMemberName] string propertyName = "",
         Action onChanged = null)
      {
         if (EqualityComparer<T>.Default.Equals(backingStore, value))
            return false;

         backingStore = value;
         onChanged?.Invoke();
         OnPropertyChanged(propertyName);
         return true;
      }

      #region INotifyPropertyChanged
      public event PropertyChangedEventHandler PropertyChanged;
      protected void OnPropertyChanged([CallerMemberName] string propertyName = "")
```

```
        {
            var changed = PropertyChanged;
            if (changed == null)
                return;

            changed.Invoke(this, new PropertyChangedEventArgs(propertyName));
        }
        #endregion
    }
}
```

FrogDetailViewModel.cs

```
using System;
using System.Diagnostics;
using Xamarin.Forms;

namespace XamarinFormsFromScratch.ViewModel
{
    [QueryProperty(nameof(SpeciesLatin), nameof(SpeciesLatin))]
    public class FrogDetailViewModel : BaseViewModel
    {
        private string speciesLatin;
        private string speciesEnglish;
        private string description;
        private string rangeAndHabitat;
        private string call;
        private string similarSpecies;

        public string SpeciesLatin
        {
            get
            {
                return speciesLatin;
            }
            set
            {
                speciesLatin = value.Replace("%20", " ");
                LoadFrogSpecies(value);
            }
        }

        public string SpeciesEnglish
        {
            get => speciesEnglish;
            set => SetProperty(ref speciesEnglish, value);
        }

        public string Description
        {
            get => description;
            set => SetProperty(ref description, value);
        }

        public string RangeAndHabitat
```

```
        {
            get => rangeAndHabitat;
            set => SetProperty(ref rangeAndHabitat, value);
        }

        public string Call
        {
            get => call;
            set => SetProperty(ref call, value);
        }

        public string SimilarSpecies
        {
            get => similarSpecies;
            set => SetProperty(ref similarSpecies, value);
        }
        // change to a non async void function
        public async void LoadFrogSpecies(string frogSpecies)
        {
            try
            {
                frogSpecies = frogSpecies.Replace("%20", " ");
                var frog = await FrogStore.GetFrogAsync(frogSpecies);

                SpeciesEnglish = frog.SpeciesEnglish;
                Description = frog.Description;
                SimilarSpecies = frog.SimilarSpecies;
                Call = frog.Calls;
                RangeAndHabitat = frog.RangeAndHabitat;
                Title = speciesLatin + $" ({speciesEnglish})";
            }
            catch (Exception)
            {
                Debug.WriteLine("Failed to load frog");
            }
        }
    }
}
```

MainPageViewModel.cs

```
using System;
using Xamarin.Forms;
using Xamarin.Essentials;
using System.Windows.Input;

namespace XamarinFormsFromScratch.ViewModel
{
    public class MainPageViewModel : BaseViewModel
    {

        private string filePath;
        private int viewSelected = 0; // 0 = mapselect; 1 = mapview
        public ICommand Button_Command { private set; get; }
```

```
        //This is the variable that will display at the top of each page

        public int ViewSelected
        {
            get { return viewSelected; }
            set { SetProperty(ref viewSelected, value); }
        }
        public string FilePath
        {
            get => filePath;
            set
            {
                filePath = value;
            }
        }

        public MainPageViewModel()
        {
            Title = "Pick Map File";

            Button_Command = new Command(
                execute: async() =>
                {
                    try
                    {
                        var result = await FilePicker.PickAsync();
                        if (result != null)
                        {
                            var Text = $"File Name: {result.FileName}";
                            if (result.FileName.EndsWith("mmpk", StringComparison.OrdinalIgnoreCase))
                            {
                                FilePath = result.FullPath;
                                (Shell.Current.BindingContext as ShellViewModel).FileSelected = true;
                                (Shell.Current.BindingContext as ShellViewModel).MapFilePath = FilePath;
                                await Shell.Current.GoToAsync("//FlyoutItems/MapPage");
                            };
                        };
                    }
                    catch (Exception ex)
                    {
                        await Application.Current.MainPage.DisplayAlert("Error", ex.ToString(), "OK");
                    }

                });
        }
    }
}
```

MapPageViewModel.cs

```
using System;
using System.Linq;
using Esri.ArcGISRuntime.Mapping;
using Xamarin.Forms;
```

```
namespace XamarinFormsFromScratch.ViewModel
{
   [QueryProperty(nameof(FilePath), "filePath")]
   public class MapPageViewModel : BaseViewModel
   {
      private string filePath;
      private Map map_Content;
      public string FilePath {
         get => filePath;
         set => SetProperty(ref filePath, value);
      }

      public Map Map_Content {
         get => map_Content;
         set => SetProperty(ref map_Content, value);
      }

      public MapPageViewModel()
      {
         FilePath = (Shell.Current.BindingContext as ShellViewModel).MapFilePath;
         Load_Map_Content(FilePath);
      }
      public async void Load_Map_Content(string path)
      {
         Title = "Map";
         try
         {
            MobileMapPackage mobileMapPackage = await MobileMapPackage.OpenAsync(path);
            await mobileMapPackage.LoadAsync();

            Map_Content = mobileMapPackage.Maps.First();

            //error may be due to the loaded async
            //LayerCollection allLayers = mobileMapPackage.Maps.First().OperationalLayers;
            //Layer Hexagon_Overlay = mobileMapPackage.Maps.First().OperationalLayers.First();
            //Layer Cell_intersections = mobileMapPackage.Maps.First().OperationalLayers.Last();
            //mobileMapPackage.Close();
            //Base_Map.OperationalLayers.Add(Hexagon_Overlay);
            //Base_Map.OperationalLayers.Add(Cell_intersections);
         }
         catch (Exception ex)
         {
            await Application.Current.MainPage.DisplayAlert("Error", ex.ToString(), "OK");
         }
      }
   }
}
```

NearbyFrogsViewModel.cs

```
using System;
using System.Collections.ObjectModel;
using System.Diagnostics;
using System.Threading.Tasks;
```

```
using Xamarin.Forms;
using XamarinFormsFromScratch.Models;
using XamarinFormsFromScratch.Views;

namespace XamarinFormsFromScratch.ViewModel
{
   public class NearbyFrogsViewModel : BaseViewModel
   {
      private FrogSpecies _selectedItem;

      public ObservableCollection<FrogSpecies> Frogs { get; }
      public Command LoadFrogsCommand { get; }
      public Command<FrogSpecies> ItemTapped { get; }

      public NearbyFrogsViewModel()
      {
         Title = "Local Frogs";
         Frogs = new ObservableCollection<FrogSpecies>();
         LoadFrogsCommand = new Command(async () => await ExecuteLoadFrogsCommand());
         ItemTapped = new Command<FrogSpecies>(OnFrogSelected);
      }
      async Task ExecuteLoadFrogsCommand()
      {
         IsBusy = true;

         try
         {
            Frogs.Clear();
            var frogs = await FrogStore.GetFrogAsync(true);
            foreach (var frogSpecies in frogs)
            {
               Frogs.Add(frogSpecies);
            }
         }
         catch (Exception ex)
         {
            Debug.WriteLine(ex);
         }
         finally
         {
            IsBusy = false;
         }
      }

      public void OnAppearing()
      {
         IsBusy = true;
         SelectedFrog = null;
      }
      public FrogSpecies SelectedFrog
      {
         get => _selectedItem;
         set
         {
            SetProperty(ref _selectedItem, value);
            OnFrogSelected(value);
```

```
        }
    }
    //change to a non async void function
    async void OnFrogSelected(FrogSpecies frog)
    {
        if (frog == null)
            return;

        await
Shell.Current.GoToAsync($"{nameof(FrogDetailPage)}?{nameof(FrogDetailViewModel.SpeciesLatin)}=
{frog.SpeciesLatin}");
    }
  }
}
```

ShellViewModel.cs

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

using Xamarin.Forms;

namespace XamarinFormsFromScratch.ViewModel
{
  public class ShellViewModel : BaseViewModel
  {
    private bool _fileSelected;
    private string _mapFilePath;

    public bool FileSelected
    {
      get => _fileSelected;
      set
      {
        if(_fileSelected != value)
        {
          _fileSelected = value;

        }

      }
    }

    public string MapFilePath
    {
      get => _mapFilePath;
      set => SetProperty(ref _mapFilePath, value);
    }
  }
}
```

Appendix D: Views

FrogDetailPage.xaml

```
<?xml version="1.0" encoding="utf-8" ?>
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="XamarinFormsFromScratch.Views.FrogDetailPage"
             Title="{Binding Title}">

    <ScrollView>
        <StackLayout Spacing="25" Padding="20">

            <Frame BackgroundColor="{StaticResource Secondary}" CornerRadius="10">
                <StackLayout>
                    <Label Text="Description:" FontSize="Large" FontAttributes="Bold"/>
                    <Label Text ="{Binding Description}" Margin="20,0,0,0" FontSize="Medium"/>
                </StackLayout>
            </Frame>

            <Frame BackgroundColor="{StaticResource Secondary}" CornerRadius="10">
                <StackLayout>
                    <Label Text="Similar Species:" FontSize="Large" FontAttributes="Bold"/>
                    <Label Text="{Binding SimilarSpecies}" Margin="20,0,0,0" FontSize="Medium"/>
                </StackLayout>
            </Frame>

            <Frame BackgroundColor="{StaticResource Secondary}" CornerRadius="10">
                <StackLayout>
                    <Label Text="Call:" FontSize="Large" FontAttributes="Bold"/>
                    <Label Text="{Binding Call}" Margin="20,0,0,0" FontSize="Medium"/>
                </StackLayout>
            </Frame>

            <Frame BackgroundColor="{StaticResource Secondary}" CornerRadius="10">
                <StackLayout>
                    <Label Text="Range and Habitat:" FontSize="Large" FontAttributes="Bold"/>
                    <Label Text ="{Binding RangeAndHabitat}" Margin="20,0,0,0" FontSize="Medium"/>
                </StackLayout>
            </Frame>

        </StackLayout>
    </ScrollView>
</ContentPage>
```

FrogDetailPage.xaml.cs

```
using Xamarin.Forms;
using XamarinFormsFromScratch.ViewModel;

namespace XamarinFormsFromScratch.Views
{
    public partial class FrogDetailPage : ContentPage
    {
```

```
        public FrogDetailPage()
        {
            InitializeComponent();
            BindingContext = new FrogDetailViewModel();
        }
    }
}
```

MainPage.xaml

```
<?xml version="1.0" encoding="utf-8" ?>
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="XamarinFormsFromScratch.Views.MainPage"
             Title="{Binding Title}">

    <!--  Body of the page  -->
    <ContentPage.Resources>
        <ControlTemplate x:Key="MapSelect" x:Name="MapSelect" >
            <Grid>
                <StackLayout x:Name="File_Select_Button">
                    <Frame Padding="24" CornerRadius="0" BackgroundColor="{StaticResource Primary}">
                        <Label Text="Welcome to the Frog Map" HorizontalTextAlignment="Center"
TextColor="White" FontSize="36"></Label>
                    </Frame>

                    <Button Text="Pick File Path" Command="{TemplateBinding
BindingContext.Button_Command}"></Button>
                </StackLayout>
            </Grid>
        </ControlTemplate>
    </ContentPage.Resources>
</ContentPage>
```

MainPage.xaml.cs

```
using XamarinFormsFromScratch.ViewModel;
using Xamarin.Forms;

namespace XamarinFormsFromScratch.Views
{
    public partial class MainPage : ContentPage
    {

        public MainPage()
        {
            InitializeComponent();
            BindingContext = new MainPageViewModel();
            ControlTemplate = MapSelect;
        }

    }
}
```

MapPage.xaml

```
<?xml version="1.0" encoding="utf-8" ?>
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="XamarinFormsFromScratch.Views.MapPage"
             xmlns:esriUI="clr-
namespace:Esri.ArcGISRuntime.Xamarin.Forms;assembly=Esri.ArcGISRuntime.Xamarin.Forms"
             Title="{Binding Title}">


    <Grid>
        <esriUI:MapView x:Name="MainMapView" Map="{Binding Map_Content}"
GeoViewTapped="MainMapView_GeoViewTapped"/>
    </Grid>
</ContentPage>
```

MapPage.xaml.cs

```
using System;
using System.Collections.Generic;
using Esri.ArcGISRuntime.Data;
using Esri.ArcGISRuntime.Xamarin.Forms;
using XamarinFormsFromScratch.ViewModel;
using Xamarin.Essentials;
using Xamarin.Forms;

namespace XamarinFormsFromScratch.Views
{
    public partial class MapPage : ContentPage
    {
        public MapPage()
        {
            InitializeComponent();
            BindingContext = new MapPageViewModel();//check if filepath excists and then switch between
telling the perosn to
        }

        private async void GetCurrentGeolocation()
        {
            try
            {
                var location = await Geolocation.GetLastKnownLocationAsync();
                if (location == null)
                {
                    var request = new GeolocationRequest(GeolocationAccuracy.Medium,
TimeSpan.FromSeconds(10));
                    location = await Geolocation.GetLocationAsync(request);
                    if (location != null)
                    {
                        //geoLocation = location;
                    }
                }
                else
                {
```

```
                //geoLocation = location;
            }
        }
        catch (Exception ex)
        {
            // Unable to get location
        }
    }

    private async void MainMapView_GeoViewTapped(object sender, GeoViewInputEventArgs e)
    {
        try
        {
            IReadOnlyList<IdentifyLayerResult> identifyResults = await
MainMapView.IdentifyLayersAsync(e.Position, 15, false, 10);
            string result = "";
            foreach (IdentifyLayerResult layerResult in identifyResults)
            {
                result = result + layerResult.LayerContent.Name + ": " +
recursivelyCountIdentifyResultsForSublayers(layerResult) + "\n";
            }
            if (!String.IsNullOrEmpty(result))
            {
                await Application.Current.MainPage.DisplayAlert("Identify result", result, "OK");
            }
        }
        catch (Exception ex)
        {
            await Application.Current.MainPage.DisplayAlert("Error", ex.ToString(), "OK");
        }
        await Shell.Current.GoToAsync($"///{nameof(NearbyFrogsPage)}");
    }
    private int recursivelyCountIdentifyResultsForSublayers(IdentifyLayerResult result)
    {
        int sublayerResultCount = 0;
        foreach (IdentifyLayerResult res in result.SublayerResults)
        {
            // This function calls itself to count results on sublayers.
            sublayerResultCount += recursivelyCountIdentifyResultsForSublayers(res);
        }

        return result.GeoElements.Count + sublayerResultCount;
    }
  }
}
```

NearbyFrogsPage.xaml

```
<?xml version="1.0" encoding="utf-8" ?>
<ContentPage xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="XamarinFormsFromScratch.Views.NearbyFrogsPage"
             Title="{Binding Title}"
             xmlns:local="clr-namespace:XamarinFormsFromScratch.ViewModel"
             xmlns:model="clr-namespace:XamarinFormsFromScratch.Models"
```

```
        x:Name="BrowseFrogsPage">

  <ContentPage.Content>
    <RefreshView x:DataType="local:NearbyFrogsViewModel" Command="{Binding
LoadFrogsCommand}" IsRefreshing="{Binding IsBusy, Mode=TwoWay}">
      <CollectionView x:Name="ItemsListView"
          ItemsSource="{Binding Frogs}"
          SelectionMode="None">
        <CollectionView.ItemTemplate>
          <DataTemplate>
            <Frame Padding="5">
              <Frame CornerRadius="10" BorderColor="Black" BackgroundColor="{StaticResource
Secondary}" Padding="0">
                <StackLayout Padding="10" x:DataType="model:FrogSpecies" >
                  <Label Text="{Binding SpeciesLatin}"
                LineBreakMode="NoWrap"
                Style="{DynamicResource ListItemTextStyle}"
                FontSize="20"/>
                  <Label Text="{Binding SpeciesEnglish}"
                LineBreakMode="NoWrap"
                Style="{DynamicResource ListItemDetailTextStyle}"
                FontSize="16"/>
                  <StackLayout.GestureRecognizers>
                    <TapGestureRecognizer
                NumberOfTapsRequired="1"
                Command="{Binding Source={RelativeSource AncestorType={x:Type
local:NearbyFrogsViewModel}}, Path=ItemTapped}"
                CommandParameter="{Binding .}">
                    </TapGestureRecognizer>
                  </StackLayout.GestureRecognizers>
                </StackLayout>
              </Frame>
            </Frame>
          </DataTemplate>
        </CollectionView.ItemTemplate>
      </CollectionView>
    </RefreshView>
  </ContentPage.Content>
</ContentPage>
```

NearbyFrogsPage.xaml.cs

```
using XamarinFormsFromScratch.ViewModel;
using Xamarin.Forms;
using Xamarin.Forms.Xaml;

namespace XamarinFormsFromScratch.Views
{
  [XamlCompilation(XamlCompilationOptions.Compile)]
  public partial class NearbyFrogsPage : ContentPage
  {
    NearbyFrogsViewModel _viewModel;
    public NearbyFrogsPage()
    {
      InitializeComponent();
```

```
            BindingContext = _viewModel = new NearbyFrogsViewModel();
        }
        protected override void OnAppearing()
        {
            base.OnAppearing();
            _viewModel.OnAppearing();
        }
    }
}
```

Appendix E: App shell

App.xaml

```
<?xml version="1.0" encoding="utf-8" ?>
<Application xmlns="http://xamarin.com/schemas/2014/forms"
             xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
             x:Class="XamarinFormsFromScratch.App">
   <Application.Resources>
      <ResourceDictionary>
         <Color x:Key="Primary">#2196F3</Color>
         <Color x:Key="Secondary">#e3f2fe</Color>
         <Style TargetType="Button">
            <Setter Property="TextColor" Value="Black"></Setter>
            <Setter Property="VisualStateManager.VisualStateGroups">
               <VisualStateGroupList>
                  <VisualStateGroup x:Name="CommonStates">
                     <VisualState x:Name="Normal">
                        <VisualState.Setters>
                           <Setter Property="BackgroundColor" Value="{StaticResource Secondary}" />
                           <Setter Property="CornerRadius" Value="10" />
                        </VisualState.Setters>
                     </VisualState>
                     <VisualState x:Name="Disabled">
                        <VisualState.Setters>
                           <Setter Property="BackgroundColor" Value="#332196F3" />
                        </VisualState.Setters>
                     </VisualState>
                  </VisualStateGroup>
               </VisualStateGroupList>
            </Setter>
         </Style>
         <Style TargetType="Label">
            <Setter Property="TextColor" Value="Black"></Setter>
         </Style>
      </ResourceDictionary>
   </Application.Resources>
</Application>
```

App.xaml.cs

```
using System;
using Xamarin.Forms;
using XamarinFormsFromScratch.Views;
using XamarinFormsFromScratch.Services;
using Xamarin.Forms.Xaml;

namespace XamarinFormsFromScratch
{
   public partial class App : Application
   {
      public App()
      {
         InitializeComponent();
```

```
            MainPage = new AppShell();
        }
    }
}
```

AppShell.xaml

```
<?xml version="1.0" encoding="utf-8" ?>
<Shell xmlns="http://xamarin.com/schemas/2014/forms"
       xmlns:x="http://schemas.microsoft.com/winfx/2009/xaml"
       xmlns:local="clr-namespace:XamarinFormsFromScratch.Views"
       Title="XamarinFormsFromScratch"
       x:Class="XamarinFormsFromScratch.AppShell">

    <Shell.Resources>
        <ResourceDictionary>

            <!--This is the base style for all elements-->
            <Style x:Key="BaseStyle" TargetType="Element">
                <Setter Property="Shell.BackgroundColor" Value="{StaticResource Primary}" />
                <Setter Property="Shell.ForegroundColor" Value="White" />
                <Setter Property="Shell.TitleColor" Value="White" />
                <Setter Property="Shell.DisabledColor" Value="#B4FFFFFF" />
                <Setter Property="Shell.UnselectedColor" Value="#95FFFFFF" />
                <Setter Property="Shell.TabBarBackgroundColor" Value="{StaticResource Primary}" />
                <Setter Property="Shell.TabBarForegroundColor" Value="White"/>
                <Setter Property="Shell.TabBarUnselectedColor" Value="#95FFFFFF"/>
                <Setter Property="Shell.TabBarTitleColor" Value="White"/>
            </Style>

            <!--Sets the tab bar and flyout's style to the base style-->
            <Style TargetType="TabBar" BasedOn="{StaticResource BaseStyle}" />

            <!--Style for how the FlyoutMenu looks-->
            <Style Class="FlyoutItemLayoutStyle" TargetType="Layout" ApplyToDerivedTypes="True">
                <Setter Property="BackgroundColor" Value="LightBlue"></Setter>
                <Setter Property="VisualStateManager.VisualStateGroups">
                    <VisualStateGroupList>
                        <VisualStateGroup x:Name="CommonStates">
                            <VisualState x:Name="Normal">
                                <VisualState.Setters>
                                    <Setter Property="BackgroundColor" Value="White" />
                                    <Setter TargetName="FlyoutItemLabel" Property="Label.TextColor"
Value="{StaticResource Primary}" />
                                </VisualState.Setters>
                            </VisualState>
                            <VisualState x:Name="Selected">
                                <VisualState.Setters>
                                    <Setter Property="BackgroundColor" Value="{StaticResource Primary}" />
                                </VisualState.Setters>
                            </VisualState>
                        </VisualStateGroup>
                    </VisualStateGroupList>
                </Setter>
            </Style>
```

```
        <Style Class="MenuItemLayoutStyle" TargetType="Layout" ApplyToDerivedTypes="True">
          <Setter Property="VisualStateManager.VisualStateGroups">
            <VisualStateGroupList>
              <VisualStateGroup x:Name="CommonStates">
                <VisualState x:Name="Normal">
                  <VisualState.Setters>
                    <Setter TargetName="FlyoutItemLabel" Property="Label.TextColor"
Value="{StaticResource Primary}" />
                  </VisualState.Setters>
                </VisualState>
              </VisualStateGroup>
            </VisualStateGroupList>
          </Setter>
        </Style>
      </ResourceDictionary>
    </Shell.Resources>

    <FlyoutItem Title="Pick Map File" Route="FlyoutItems">
      <ShellContent Route="MainPage" ContentTemplate="{DataTemplate local:MainPage}" />
    </FlyoutItem>

    <FlyoutItem Title="Map" Route="FlyoutItems">
      <ShellContent Route="MapPage" ContentTemplate="{DataTemplate local:MapPage}"
IsVisible="true"/>
    </FlyoutItem>

    <FlyoutItem Title="All Frogs" Route="FlyoutItems">
      <ShellContent Route="NearbyFrogsPage" ContentTemplate="{DataTemplate
local:NearbyFrogsPage}" />
    </FlyoutItem>



</Shell>
```

AppShell.xaml.cs

```
using XamarinFormsFromScratch.Views;
using XamarinFormsFromScratch.ViewModel;
using Xamarin.Forms;
using XamarinFormsFromScratch.Services;

namespace XamarinFormsFromScratch
{
    public partial class AppShell : Xamarin.Forms.Shell
    {
        public AppShell()
        {
            InitializeComponent();
            BindingContext = new ShellViewModel();
            DependencyService.Register<FrogSpeciesDataStore>();
            Routing.RegisterRoute(nameof(FrogDetailPage), typeof(FrogDetailPage));
        }
    }
}
```

Appendix F: FrogSpeciesInfo

FrogSpeciesInfoXML.xml


```
<?xml version="1.0" encoding="utf-8" ?>
<ArrayOfFrogSpecies xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">
	<!--
	Template for Frogs
	<FrogSpecies>
	<SpeciesLatin></SpeciesLatin>
	<SpeciesEnglish></SpeciesEnglish>
	<Description></Description>
	<SimilarSpecies></SimilarSpecies>
	<Calls></Calls>
	<RangeAndHabitat></RangeAndHabitat>
	<PageNumber></PageNumber>
	</FrogSpecies>
	-->
	<FrogSpecies>
	<SpeciesLatin>Smilisca Sordida</SpeciesLatin>
	<SpeciesEnglish>Drab Treefrog</SpeciesEnglish>
	<Description>Smilisca sordida is a medium-sized frog (~30– 55mm; ~1.2– 2.2in males; ~55–
65mm ~2.2– 2.6in females). The skin is smooth dorsally and granular ventrally. The eyes are large, with
horizontal pupils. Tympanic membranes and subtle supratympanic folds are present. Dorsal coloration is
variable ranging from shades of gray to brown with darker longitudinal blotches dorsally sometimes
connecting medially, and slightly darker bars on the dorsum of the limbs. The groin has dark reticulations
contrasting with light gray or pale blue spots. The posterior thigh is similarly marked. The ventral color
ranges from white to cream. The fingers and toes have webbing and expanded terminal pads. Males have
dark nuptial pads, and gray, paired subgular vocal sacs.</Description>
	<SimilarSpecies>Smilisca sordida may be confused with other brown/tan treefrogs.
Trachycephalus typhonius is larger with distinct dark vertical bars and/or reticulations on the iris. Boana
rosenbergi differs in having a dark dorsal pinstripe. Isthmohyla pseudopuma lack the reticulated groin.
Other Smilisca are similar, but S. phaeota has dark, vein-like markings on the flank and a dark mask, and S.
baudinii has brown groin and posterior thigh marked with light spots, and usually a pale suborbital spot.
Smilisca sila is most similar, but is pug-nosed and has tuberculate skin dorsally</SimilarSpecies>
	<Calls>Males call after rains during the dry season from rocks and low vegetation associated with
small, rocky streams. The call is a rapidly repeated “krriid”</Calls>
	<RangeAndHabitat>A common species found in association with forest streams ranging from near
sea level to ~1,550m, including some gallery forests on the northern Pacific versant.</RangeAndHabitat>
	<PageNumber>174</PageNumber>
	</FrogSpecies>

	<FrogSpecies>
	<SpeciesLatin>Tlalocohyla Loquax</SpeciesLatin>
	<SpeciesEnglish>Loquacious Treefrog</SpeciesEnglish>
	<Description>Tlalocohyla loquax is small to moderatesized (~35– 45mm, ~1.4– 1.8in), but a
robustly shaped frog. The snout is rounded in profile. The dorsal coloration, which is subject to
```

metachrosis, can vary from a light yellow to dark reddish brown, often having dark spots and markings scattered throughout. On the anterior and posterior thighs, and to a lesser extent on the ventral surfaces of the thighs, there is a bright reddish-orange coloration; this reddish-orange coloration also extends down to the ventral surfaces of the lower leg and onto the interdigital webbing of the feet. The eye has a horizontal pupil, and a brown to copper colored iris. The ventral surfaces of the body, hands, and the majority of the limbs are a yellowish cream. An axillary membrane is found at the armpits. There is weak to moderate webbing on the hands, and nearly extensive webbing on the feet. Males lack nuptial pads, but have a subgular vocal sac.</Description>

<SimilarSpecies>Tlalocohyla loquax is quite different from other frog species in Costa Rica, and unlikely to be confused, especially when its unique advertisement call is added to its defining characteristics.</SimilarSpecies>

<Calls>Males call from vegetation and other structures above the water or near its surface in ponds and swamps. The advertisement call is a loud “kunk”, but at times, especially when numerous other T. loquax are calling at a site, other sounds and notes can be emitted</Calls>

<RangeAndHabitat>This relatively common nocturnal species may be found throughout much of the northern and central Caribbean lowlands and foothills, ranging in elevation from ~50 to 1,100m. This species can be found in a variety of habitats, ranging from old-growth forest to agricultural areas.</RangeAndHabitat>

<PageNumber>175</PageNumber>

</FrogSpecies>

<!--Aromobatidae-->

<FrogSpecies>

<SpeciesLatin>Allobates talamancae</SpeciesLatin>

<SpeciesEnglish>Talamancan Cryptic Forest Frog</SpeciesEnglish>

<Description>Allobates talamancae is a tiny to small-sized (~16– 25mm, ~0.6– 1in), but robust frog. A pair of cream to light brown dorsolateral stripes extend from the tip of the snout to the sacrum. The dorsum and flanks are dark brown to nearly black. On both sides of the body, along the ventrolateral region, there are contrasting white lines that extend from the upper lip to the groin. The arms and legs typically are a lighter tone, often ranging in color from tan to light orange-brown. Adult males have a black throat and chest; females have uniformly light ventral surfaces.</Description>

<SimilarSpecies>Phyllobates lugubris is similar in size and general appearance, but has yellow to yellowishwhite dorsolateral stripes and a dark venter with light bluish-white markings. Silverstoneia flotator and S. nubicola are similar in general appearance to Allobates talamancae, but both Silversoneia species have white stripes, that either extend out from the upper groin to the eye (S. nubicola and Pacific versant S. flotator) or as an incomplete stripe that simply extends out a short distance from the upper groin (Caribbean versant S. flotator).</SimilarSpecies>

<Calls>Males call during the daytime from hidden locations in the leaf litter. The advertisement call is a series of whistlelike chirps</Calls>

<RangeAndHabitat>This relatively common diurnal species inhabits a large section of humid forest in the lowlands and foothills of the eastern Caribbean versant, but has a more restricted range within the humid forests of lowlands and foothills of the southern Pacific. Allobates talamancae can be found from near seal level to ~800m.</RangeAndHabitat>

<PageNumber>44</PageNumber>

</FrogSpecies>

<!--Aromobatidae end-->

<!--Bufonidae (Atelopus)-->

<FrogSpecies>

<SpeciesLatin>Atelopus chiriquiensis</SpeciesLatin>
<SpeciesEnglish>Chiriqui Harlequin Frog</SpeciesEnglish>
<Description>Atelopus chiriquiensis is a medium-sized frog (~28– 34mm, 1.1– 1.3in males; ~36– 49mm, ~1.4– 1.9in females). The dorsal coloration differs between the sexes, with males usually a solid light green, powder blue, light tan or rust. Female coloration is variable but usually consists of contrasting stripes or reticulations of black and orange-red. The parotoid glands are low profile and elongated, and no tympanic membranes are present. The eye has a horizontal pupil and a gold iris. The ventral surfaces of the body and limbs are light colored with dark mottling. The digits lack expanded terminal pads and the fingers have limited webbing. Finger I is short and stubby as are toes I-II. The toes have moderate webbing. The snout has a strongly sloping profile. Males have brown nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Atelopus chiriquiensis is very similar to other Atelopus species in Costa Rica. However, A. varius has smoother skin and inconspicous dorsal glands, A. senex has very pronounced dorsal glands, and A. chirripoensis is only known from a single specimen from Cerro Chirripo Grande.</SimilarSpecies>
<Calls>Males are territorial and call from low perches along streams, producing a very short, buzz-like whistle or peep “wheezzt”</Calls>
<RangeAndHabitat>This formerly common, diurnal species has disappeared from its historical sites within Costa Rica and may be extinct. Any encounters with this species should be documented. Atelopus chiriquiensis were usually found in association with streams in moist forests of the Talamancas. The elevational range for A. chiriquiensis is ~1,100– 2,500m.</RangeAndHabitat>
<PageNumber>46</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Atelopus chirripoensis</SpeciesLatin>
<SpeciesEnglish>Chirripo Harlequin Frog</SpeciesEnglish>
<Description>Atelopus chirripoensis is a large toad (~60– 85mm, ~2.4– 3.4in). The dorsal coloration of the only known specimen (preserved) is a solid dark brown color. The venter was a pale, reddish orange color in life. Overall, the skin is smooth, but there are slight, raised glands/tubercles scattered on the dorsolateral surfaces. The snout is rounded, and the eyes are medium-sized with a fleshy ridge extending from the snout and over the upper eyelid. There are no tympanic memberanes; however, a glandular ridge extends from the posterior of the eye to the shoulder (insertion of the arm). The arms and legs are relatively short and stout. The digits are robust, and lack expanded terminal tips. The fingers lack webbing, but the toes have extensive, thick webbing.</Description>
<SimilarSpecies>Atelopus chirripoensis is quite unique and it is unlikely any other species of anuran within Costa Rica will be confused with A. chirripoensis. Other Atelopus species generally lack the solid dark brown dorsal coloration, and all have snouts that are more pointed and sloping in profile.</SimilarSpecies>
<Calls>Unknown</Calls>
<RangeAndHabitat>This diurnal species is only known from the subalpine paramo habitat of Cerro Chirripo Grande. The single specimen was collected from a breeding congregration in an ephemeral pond at an elevation of ~3,400– 3,500m. Despite extensive efforts, the species has not been detected since the original specimen was collected in 1980. The species is likely extinct, thus any encounters with this species are of scientific importance and should be carefully documented.</RangeAndHabitat>
<PageNumber>47</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Atelopus senex</SpeciesLatin>
<SpeciesEnglish>Wizened Harlequin Frog</SpeciesEnglish>
<Description>Atelopus senex is a medium-sized toad (~28– 32mm, ~1.1– 1.3in males; ~30– 43mm, ~ 1.2– 1.7in females). The dorsal coloration is variable, ranging from blue-gray to black in males, and similar ground color, but often with light areas of yellow, green, and/or orange in females. The venter is gray and may have dark markings. The skin is smooth, but there are very pronounced, raised glandular ridges extending from the scapulae to the sacrum, as well as glandular areas on the snout, head, elbows, knees and heels. The snout is sloping in profile. There are no tympanic membranes. An elongated parotoid gland extends from the posterior margin of they eye. The limbs are relatively long and slender. The digits lack expanded terminal tips, and the fingers lack webbing, but the toes have moderate, thick webbing. Males have brown nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Atelopus senex is most likely to be confused with other Atelopus species. The most similar in appearance is A. chiriquiensis. Males may have similar solid bluish dorsal coloration, but the glandular areas in A. chiriquiensis are much more modest. The glandular protuberances are absent in A. varius.</SimilarSpecies>
<Calls>Males call from perches in or near streams, producing a short buzzing trill</Calls>
<RangeAndHabitat>This formerly common, diurnal species has disappeared from its historical sites within Costa Rica and may be extinct. Any encounters with this species should be documented. Atelopus senex were usually found in association with streams in moist forests of the Central Volcanic range and northern Talamancas. The elevational range for A. senex is ~1,250– 2,200m.</RangeAndHabitat>
<PageNumber>48</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Atelopus varius</SpeciesLatin>
<SpeciesEnglish>Variable Harlequin Frog</SpeciesEnglish>
<Description>Atelopus varius is a medium-sized toad (~27– 39mm, ~1.1– 1.5in males; ~33-48mm, ~1.3– 1.9in females). Coloration, is variable consisting of a red, orange, yellow, or yellowish-green ground color with varying amounts of black blotches and/or spots, both dorsally and ventrally. The skin is smooth. The snout is pointed, and sloping in profile. The eyes have horizontal pupils and a light green iris. There are no tympanic membranes. The arms and legs are relatively long and slender. The digits lack expanded terminal tips, and the fingers lack webbing, but the toes have moderate, thick webbing. Males have brown nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Atelopus varius is most likely to be confused with other Atelopus species. Atelopus senex and A. chiriquiensis are most similar in form, but both have modest to pronounced glandular areas on the dorsum. Atelopus chirripoensis is much larger and presumably has a solid, dark-colored dorsum.</SimilarSpecies>
<Calls>Males are territorial and call from low perches along streams, producing a short, high pitched “peep” or “chiiip” that has a subtle rapid, buzz-like quality</Calls>
<RangeAndHabitat>This formerly common, diurnal species has disappeared from nearly all of its historical sites within Costa Rica. It was feared to be extinct until small populations were rediscovered in their southern range on the Pacific slope. Any encounters with this species should be documented. Atelopus varius are usually found in association with fast-flowing, small streams in moist forests, formerly at a wide range of elevations from near sea level to ~2,100m.</RangeAndHabitat>
<PageNumber>49</PageNumber>
</FrogSpecies>

<!--Bufonidae (Atelopus) End-->

<!--Bufonidae (Incilius)-->
<FrogSpecies>
<SpeciesLatin>Incilius aucoinae</SpeciesLatin>
<SpeciesEnglish>Rainforest Toad</SpeciesEnglish>
<Description>Incilius aucoinae is a medium to large-sized toad (~40– 65mm, ~1.6– 2.6in males; ~65– 105mm, 2.6– 4.1in females). The skin is covered with tubercles of varying sizes, forming rows that extend from the parotoid glands to the groin. The parotoid glands are trianglular and situated above the dorsolateral row of tubercles. A supratympanic fold extends from the eye to the parotoid gland. Dorsal coloration consists of browns and grays often with a pale middorsal stripe. The limbs are marked with dark transverse bands. The venter is light colored and males may have a dark gray throat and chest. The eyes have horizontal pupils and gold irises with dark reticulations. Fingers are long and slender and lack webbing. The toes are also long, but have limited webbing. Males have brown nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Incilius aucoinae may be confused with other toads. The most similar is I. melanochlorus, however they are allopatric occurring on the Atlantic versant, and have a transverse fold between the cranial crests (absent in I. aucoinae). Incilius coccifer and I. valliceps both have oval parotoid glands. Incilius luetkenii has dark, keratinized cranial crests and Rhinella horribilis has huge parotoid glands.</SimilarSpecies>
<Calls>The call for this species has not been formally described, but it is a short trill, similar to the call of the closely related Incilius melanochlorus</Calls>
<RangeAndHabitat>This common nocturnal species is found in moist to wet forests of the Pacific versant, with a disjunct population occuring in the Central Volcanic region. During the breeding season (dry season) they are found in or near slow moving streams and rivers with rocky substrates at elevations ranging from near sea level to ~750m.</RangeAndHabitat>
<PageNumber>50</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius chompipe</SpeciesLatin>
<SpeciesEnglish>Central Volcanic Dwarf Toad</SpeciesEnglish>
<Description>Incilius chompipe is a small toad (~22– 34mm, 0.9– 1.3in), but robust and highly tuberculate with nearly fully webbed hands and feet. The dorsal skin has an overall rough texture with numerous pointed to rounded tubercles. Along the upper lateral surface of the body there is a row of larger pointed to rounded tubercles that extend from the groin to the posterior edge of the raised triangular parotoid gland. The snout is pointed in both dorsal and lateral views. The coloration of the dorsum is typically a mixture of different shades of brown, but some individuals also have lighter orange blotches and tubercles. Finger I is completely embedded in pad-like webbing.</Description>
<SimilarSpecies>Incilius epioticus and Incilius guanacaste are the closest related taxa and are very similar to I. chompipe morphologically. Both I. epioticus and I. guanacaste are known to be allopatrically distributed from I. chompipe. Incilius epioticus is known to inhabit the Talamancan mountains, while I. guanacaste is only known from the Miravalles and Rincón de la Vieja Volcanoes.</SimilarSpecies>
<Calls>The advertisement call for this species is unknown.</Calls>
<RangeAndHabitat>Incilius chompipe is endemic to Costa Rica, and only known to inhabit cloud forests from ~1,400 to 2,250m within the Central Volcanic Range. This uncommon species had only been reported from the slopes of the Barva and Irazú volcanoes, but was also recently found along the eastern slopes of the Turrialba Volcano at 2,250m (B. Kubicki, pers. observ.). Very little is known

about the biology of I. chompipe but captive reproduction demonstrated they have direct development, and it is now known that they utilize axillary amplexus (B. Kubicki, pers. observ.).</RangeAndHabitat>
<PageNumber>51</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius coccifer</SpeciesLatin>
<SpeciesEnglish>Dry Forest Toad</SpeciesEnglish>
<Description>Incilius coccifer is a medium to large-sized toad (~45– 65mm, ~1.8– 2.6in males; ~53– 83mm, 2.1– 3.3in females). The skin is covered in spiny tubercles (especially laterally). Dorsal coloration is tan to brown with darker blotches. A light colored interorbital bar, and a vertebral stripe occur, as do dorsolateral stripes extending from the parotoid glands to the groin. The ventral color is white with faint small dark markings. Cranial crests are present, as are supratympanic folds over visible tympanic membranes. The parotoid glands are oval. Pupils are horizontal and the iris is gold with dark reticulations. The limbs and digits are stout. Fingers lack webbing and toes have limited webbing. Males have brown nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Incilius coccifer may be confused with other toads. The most similar is I. valliceps, but they lack the light orbital bar and have a distinct row or enlarged tubercles laterally. Incilius aucoinae and I. melanochrous both have smaller, triangular parotoid glands. Incilius luetkenii has dark keratinized cranial crests, and Rhinella horribilis has huge parotoid glands.</SimilarSpecies>
<Calls>During the rainy season, males call from flooded fields, ponds and puddles, producing a buzz-like call</Calls>
<RangeAndHabitat>This common nocturnal species is found in a variety of habitats ranging from forests, fields, open areas and even urban locations. They occur on the Pacific versant and in the Central Valley; the elevational range is from near sea level to ~1,400m.</RangeAndHabitat>
<PageNumber>52</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius coniferus</SpeciesLatin>
<SpeciesEnglish>Green Climbing Toad</SpeciesEnglish>
<Description>Incilius coniferus is a moderate to largesized toad (~53– 72mm, ~2.1– 2.8in males; 76– 94mm, 3– 3.7in females). The skin is covered in scattered tubercles that may have black keratinized tips. A dorsolateral row of enlarged tubercles extends from the parotoid gland to the groin. Dorsal ground coloration is highly variable, often ranging from tan, brown, yellow to green, with scattered darker blotches. The venter is light colored with scattered, small dark markings. Cranial crests are present, as are supratympanic folds over large, visible tympanic membranes. The parotoid glands are usually small. The snout tapers anteriorly and the evident nostrils are protuberant. Pupils are horizontal and the iris varies in color but has fine, dark reticulations. The limbs are long and the hands are large, with long fingers (finger II longer than finger I). Fingers lack webbing, but toes have limited to moderate webbing. Males have dark nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Incilius coniferus may be confused with other toads; however, other toads are rarely green in color. The most similar is I. valliceps, but they have much larger parotoid glands. Incilius aucoinae and I. melanochrous both have triangular parotoid glands. Incilius luetkenii has shorter fingers, and Rhinella horribilis has huge parotoid glands.</SimilarSpecies>
<Calls>During the dry season, males call from pools and puddles, producing a very long, pulsating trill</Calls>
<RangeAndHabitat>This common nocturnal species is found in moist to wet forests at elevations ranging from near sea level to ~1,700m. As their common name suggests, they may be found

climbing in lower vegetation. They occur on both the Pacific and Atlantic versants, but are absent from the dry forests of Guanacaste and from the Central Valley.</RangeAndHabitat>
<PageNumber>53</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius epioticus</SpeciesLatin>
<SpeciesEnglish>Talamancan Dwarf Toad</SpeciesEnglish>
<Description>Incilius epioticus is a small to mediumsized toad (~23– 37mm, ~0.9–1.5in). The dorsal coloration is brown to brownishgray, occasionally with orange or red spots, and the venter is a lighter shade of brown. The skin is densely covered in small tubercles producing a rough appearance. The snout is pointed and cranial crests extend from the tip of the snout posteriorly over the eyes, to the rounded parotoid glands. Tympanic membranes are absent. The eyes have a horizontal pupil and brown or golden iris. A row of tubercles extends from the parotoid gland to the groin. The hands and feet have thick webbing. Males have light colored nuptial pads, but lack a vocal sac.</Description>
<SimilarSpecies>Incilius chompipe and Incilius guanacaste are closely related and very similar in appearance to I. epioticus and could be very difficult to distinguish. However, both I. chompipe and I. guanacaste are allopatrically distributed from I. epioticus. Incilius chompipe is known to inhabit the Central Volcanic mountains, while I. guanacaste is only known from the Miravalles and Rincón de la Vieja Volcanoes.</SimilarSpecies>
<Calls>The advertisement call for this species is unknown.</Calls>
<RangeAndHabitat>Incilius epioticus is a diurnal toad that is rarely encountered. They occur on the Atlantic versant of the Talamancas at elevations ranging from ~1,700 to 2,050m. They are found in mature, moist to wet forests with deep leaf litter in which they hide, and are likely fossorial much of the year.</RangeAndHabitat>
<PageNumber>54</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius fastidiosus</SpeciesLatin>
<SpeciesEnglish>Disdainful Toad</SpeciesEnglish>
<Description>Incilius fastidiosus is a medium-sized toad (~43– 60mm, ~1.7– 2.4in). They have numerous welldeveloped warts on the body and limbs giving them a bumpy texture. The warts and tubercles are pale orangish-tan contrasting with the dark brown ground color. Enlarged warts form a lateral row. Large cranial crests extend from the snout to the posterior margin of the eye, and abut oval parotoid glands. They lack tympanic membranes. The eyes are large with a horizontal pupil and a dark iris. The ventral surface of the body is granular and darkly colored with light mottling. Webbing exists between the fingers, as does a thick webbing between the toes. Males lack vocal sacs, but have pale nuptial pads.</Description>
<SimilarSpecies>Incilius fastidiosus is most likely to be confused with closely related I. holdridgei. They may be distinguished by the more abundant and pronounced lateral warts, and more developed cranial crests on I. fastidiosus. Further, the species are allopatric, with I. holdridgei occurring in the Central Volcanic Range.</SimilarSpecies>
<Calls>Males do not produce advertisement calls. Nevertheless, during breeding congregations males may produce a quiet trill as a release call when amplexed by another male.</Calls>
<RangeAndHabitat>This diurnal species occurs in premontane and montane cloud forests of the Talamancas at elevations between ~750– 2,400m. They may be found in pools or stream edges during the brief breeding period following the first heavy rains of the year (April and May). Other times of

the year they occur in leaf litter. Incilius fastidiosus has experienced severe declines and may now be extinct. Any encounters with this species should be documented.</RangeAndHabitat>
<PageNumber>55</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius guanacaste</SpeciesLatin>
<SpeciesEnglish>Guanacaste Mountain Dwarf Toad</SpeciesEnglish>
<Description>Incilius guanacaste is a small-sized toad (~20– 25mm, ~0.8– 1in) with a robust body and short limbs. The dorsal coloration is brown to brownish-gray, occasionally with pale spots, especially on the hands and feet. The venter is also dark gray or brown. The skin (dorsal and ventral) is covered in small, rounded tubercles producing a rough appearance, and an indistinct lateral row of tubercles is present on each side. The snout is pointed and cranial crests extend from the tip of the snout posteriorly over the eyes, to the tiny, triangular parotoid glands. Tympanic membranes are absent. The eyes have a horizontal pupil and a brown iris. The hands and feet have thick webbing, with finger I entirely encompassed in webbing, and all of the toes fully webbed. Males lack both a vocal sac, and nuptial pads.</Description>
<SimilarSpecies>Incilius guanacaste may be confused with closely related I. chompipe and I. epioticus. Incilius chompipe has much larger, and often more pointed tubercles, including a more distinct lateral row. Incilius epioticus differs in also having larger turbcles, including a lateral row, as well as larger oval parotoid glands. All three species are allopatrically distributed. Incilius epioticus occurs in the Talamancas, whereas I. chompipe occurs in the Central Volcanic mountains.</SimilarSpecies>
<Calls>The advertisement call for this species is unknown.</Calls>
<RangeAndHabitat>Incilius guanacaste is a diurnal toad that is rarely encountered. They occur on the Miravalles and Rincón de la Vieja Volcanoes at elevations ranging from ~1,700 to 2,000m. The are found in mature, premontane and montane rainforests with deep leaf litter in which they hide. They are likely fossorial much of the year.</RangeAndHabitat>
<PageNumber>56</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius holdridgei</SpeciesLatin>
<SpeciesEnglish>Holdridge’s Toad</SpeciesEnglish>
<Description>Incilius holdridgei is a medium-sized toad (~32– 53mm, ~1.3– 2.1in). The skin has a rough or bumpy appearance due to the numerous tubercles of various sizes. The eyes have horizontal pupils and a dark/ black iris. Tympanic membranes are absent. Slight cranial crests (supraocular ridges) extend posteriorly to the small round parotoid glands. The dorsal coloration is black or brown with pale red or orangish spots associated with tubercles. A lateral row of large turbcles extend from the eye to the groin, and are often marked with a pale line. The venter is granular, and is mottled with black and cream blotches. The limbs are similar in length, and the hands and feet are webbed. The thick webbing on the toes is moderate, whereas the fingers have limited webbing. Males have light nuptial pads, but lack a vocal sac.</Description>
<SimilarSpecies>Incilius holdridgei may be confused with the closely related Incilius fastidiosus. However, I. fastidiosus has much more pronounced cranial crests and is larger in overall size. Further, I. fastidiosus is allopatric, occurring in the eastern Talamancas.</SimilarSpecies>
<Calls>Incilius holdridgei is not known to call.</Calls>
<RangeAndHabitat>This rare species occurs in lower montane rainforsts of the Central Volcanics from ~1,800 to 2,200m. They are diurnal and may be found on the forest floor or under leaf litter and surface debris. Much of the year they are fossorial, and usually found on the surface only during the

brief mating period in the early rainy season (April to May). This species was believed to be extinct until rediscovered in 2010. Any encounters with the species should be documented.</RangeAndHabitat>
<PageNumber>57</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius luetkenii</SpeciesLatin>
<SpeciesEnglish>Yellow Toad</SpeciesEnglish>
<Description>Incilius luetkenii is a large-sized toad (77– 107mm, ~3– 4.2in). The dorsal skin is densely covered with rounded tubercles giving a bumpy appearance. The dorsal coloration is variable, and differs between males and females. Breeding males having a bright yellow color which can darken to a yellowish-brown (metachrosis). Females are often brown to reddish brown dorsally (sometimes yellowish), usually with a light vertebral stripe and beige lateral stripes. Large cranial crests and labial crests with black, keratinized ridges are present. The tympanic membrane is easily visible below a supratympanic ridge that abuts a small parotoid gland. The eyes have horizontal pupils and bronze-copper irises with dark reticulations. The limbs are stout. Fingers lack webbing, but the toes are moderately webbed. The venter is granular, and white to cream colored. Males have a subgular vocal sac and dark nuptial pads.</Description>
<SimilarSpecies>Incilius luetkenii breeding males are distinct and not likely to be confused with other species. However, non-yellow forms may be confused with other large Incilius species. Incilius coccifer differs in having a pale interorbital bar, middorsal pinstripe, and lacking the keratinized cranial crests. Incilius aucoinae and I. melanochlorus differ in having small triangular parotoid glands and lacking the keratinized cranial crests. Incilius valliceps has much larger parotoid glands and a lateral row of large tubercles.</SimilarSpecies>
<Calls>Males call from the edges of temporary ponds, ditches, and pools of slow-moving streams during the beginning of the rainy season (May to June). The call is a short, pulsating, low-pitched trill “brrrrrt”</Calls>
<RangeAndHabitat>This nocturnal species is common in the Guanacaste region, inhabiting dry forests, wetlands, and disturbed areas (pastures, agricultural areas). The elevational range for Incilius luetkenii is from near sea level to ~1,150m.</RangeAndHabitat>
<PageNumber>58</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Incilius melanochlorus</SpeciesLatin>
<SpeciesEnglish>Wet Forest Toad</SpeciesEnglish>
<Description>Incilius melanochlorus is a medium to largesized toad (~43– 65mm, ~2.4– 3.4in males; ~65– 103mm, ~2.6– 4.1in females). The skin is covered with tubercles of varying sizes, forming two rows extending from the parotoid glands to the groin. The parotoid glands are trianglular and situated above the dorsolateral row of tubercles. A supratympanic fold extends between the tympanic membrane and the parotoid gland, and transverse folds extend between the cranial crests. The dorsal coloration consists of browns and grays, often with a light toned middorsal stripe. The limbs are marked with dark transverse bands. The venter is light colored, but males may have a dark gray throat and chest. The eyes have horizontal pupils and gold irises with dark reticulations. Fingers are long and slender and lack webbing. The toes are also long, but have limited webbing. Males have brown nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Incilius melanochlorus may be confused with other toads. The most similar is I. aucoinae however, they are allopatric, occurring on the Pacific versant, and they lack a transverse fold between the cranial crests (present in I. melanochlorus). Incilius coccifer and I. valliceps

both have large, oval parotoid glands. Incilius luetkenii has dark, keratinized cranial crests and Rhinella horribilis has huge parotoid glands.</SimilarSpecies>

<Calls>Males may be observed calling from the edges of rocky streams during the drier season (February to April). The call is a short, pulsating, low-pitched trill “brrrrrt” similar to that of Incilius aucoinae.</Calls>

<RangeAndHabitat>This nocturnal species is found in moist to wet forests of the Atlantic versant. During the breeding season individuals may be found in or near slow moving streams and rivers with rocky substrates at elevations ranging from near sea level to ~1,400m.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Incilius periglenes</SpeciesLatin>

<SpeciesEnglish>Golden Toad</SpeciesEnglish>

<Description>Incilius periglenes is a medium-sized toad (39– 56mm, ~1.5– 2.2in). The skin is covered in low, rounded tubercles producing a rough texture. The dorsal coloration differs between males and females, with males having a solid, bright orange color, whereas females have a dark greenish-brown to black ground color with scattered red spots and blotches. Cranial crests extend posteriorly to large, oval parotoid glands. The eyes have horizontal pupils and dark irises. There are no tympanic membranes present. The venter is pale with dark mottling, and a granular. The limbs are stout and the fingers lack webbing, whereas the toes have limited webbing. Males lack a vocal sac, but have dark nuptial pads.</Description>

<SimilarSpecies>Incilius periglenes is quite unique, and unlikely to be confused with any other Costa Rican frogs or toads.</SimilarSpecies>

<Calls>Males vocalize in or near temporary pools that form within cloud forests at the very beginning of the rainy season (March to June). Although they may not produce an advertisement call (there are mixed opinions on this), they do produce a release call that is a short trill.</Calls>

<RangeAndHabitat>Incilius periglenes is endemic to Costa Rica, and only known to inhabit lower montane cloud forests near Monteverde at elevations of ~1,500 to 1,650m. This diurnal species is secretive and fossorial except for short breeding episodes (usually about a week long or less) during the very early rainy season, when they may occasionally be found on the forest floor, or more commonly, congregating at temporary pools. This toad was locally aboundant, although with an extremely limited range. This species is thought to be extinct. Consequently, any encounters with this species should be carefully documented (photos only).</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Incilius valliceps</SpeciesLatin>

<SpeciesEnglish>Gulf Coast Toad</SpeciesEnglish>

<Description>Incilius valliceps is a medium to large-sized toad (~48– 82mm, ~1.9– 3.2in). The dorsum has rounded, smooth tubercles and a lateral row of enlarged, pointed tubercles extending from the large parotoid glands to the groin. The dorsal coloration is usually tan, marked with various small dark blotches. Occasionally there is a pale vertebral stripe extending partially or completely down the back, and/or a dark interorbital bar. The lateral row of tubercles is bordered by a dark band below and a pale band above. Thick, raised cranial crests are very evident, and form a supratympanic ridge over the large tympanic membranes (nearly the size of the eye). The eyes have a horizontal pupil and a gold to reddish orange iris. The venter is pale yellow and granular. The fingers lack webbing, whereas the toes are slightly webbed. Males have dark nuptial pads, and a slightly darkened subgular vocal sac.</Description>

<SimilarSpecies>Incilius valliceps, is most likely to be confused with sympatric, large toad species in northern Costa Rica. Incilius melanochlorus has much smaller parotoid glands and weaker cranial crests. Incilius coccifer has weaker cranial crests, a white vertebral pinstripe, and a light interorbital bar. Incilius luetkenii has blackened cranial crests, much smaller parotoid glands and lacks the lateral row of tubercles. Rhinella horribilis has huge parotoid glands.</SimilarSpecies>

<Calls>Males call from in or near still water of streams, pools, and ponds. The call is a short trill that is repeated after several seconds</Calls>

<RangeAndHabitat>Incilius valliceps is an uncommon, nocturnal toad found in lowland forests of the San Juan River drainage at elevations ranging from ~50 to 500m. They may be encountered on the forest floor, often near streams or rivers.</RangeAndHabitat>

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</FrogSpecies>

<!--Bufonidae (Incilius) End-->

<!--Bufonidae (Rhaebo)-->

<FrogSpecies>

<SpeciesLatin>Rhaebo haematiticus</SpeciesLatin>

<SpeciesEnglish>Leaf Litter Toad</SpeciesEnglish>

<Description>Rhaebo haematiticus is a medium to largesized toad (~42– 62mm, ~1.7– 2.1in males; ~50– 80mm, ~2– 3.1in females). The dorsum is relatively smooth, but has scattered low tubercles. A slight fold of skin extends from the very large parotoid gland towards the groin. The dorsal coloration is variable, ranging from a light reddish brown, to darker brown or gray, with small scattered black blotches. A dark lateral band bordered above by a thin pale line extends from the snout to the groin. There are no cranial crests, but a supratympanic fold extends from the eye to the parotoid glands. The tympanic membranes are small, but visible. The eyes are large and have horizontal pupils and gold irises with dark reticulations. The venter is pale gray with a red wash, and dark mottling, that may cover much of the ventral surface. They have long arms and the digits are also long essentially lacking webbing. Males have dark nuptial pads, and a subgular vocal sac.</Description>

<SimilarSpecies>Rhaebo haematiticus is quite unique and it is unlikely to be confused with any other species of anuran within Costa Rica.</SimilarSpecies>

<Calls>Males can be heard calling from terrestrial sites near rocky pools of rivers and streams. The call is a series of rapid, short notes “peep, peep, peep”</Calls>

<RangeAndHabitat>This nocturnal species is usually found on leaf litter in moist to wet forests of both Atlantic and Pacific slopes from near sea level to ~1,300m. During the breeding season they may be found near forest streams and rivers.</RangeAndHabitat>

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</FrogSpecies>

<!--Bufonidae (Rhaebo) End-->

<!--Bufonidae (Rhinella)-->

<FrogSpecies>

<SpeciesLatin>Rhinella horribilis</SpeciesLatin>

<SpeciesEnglish>Giant Toad</SpeciesEnglish>

<Description>Rhinella horribilis is a large to giant-sized toad (~85– 145mm, ~3.3– 5.7in males; ~90– 175mm, ~3.5– 6.9in females). The dorsum is covered with scattered warts and tubercles, more pronounced in males than in females. The warts and tubercles often have keratinized spines (more prevalent in males). Cranial crests are well developed and form a suprtympanic ridge that extends to the huge parotoid gland. The tympanic membranes are large and evident. Dorsal coloration is variable, usually brown, reddish brown, yellowish brown or gray, with scattered dark blotches in females and juveniles. The

eyes have horizontal pupils and gold irises with heavy, dark reticulations. The venter is cream with dark mottling and granular. The limbs are relatively short and stocky. The fingers lack webbing but males have brown nuptial pads and a subgular vocal sac. Toes have limited webbing, and a distinct medial tarsal fold is present.</Description>

<SimilarSpecies>Adult Rhinella horribilis are not likely to be confused with any other anuran in Costa Rica. Juvenile R. horribilis may appear similar to other toad species, but the very large parotoid glands and the tarsal fold should distinguish them.</SimilarSpecies>

<Calls>Males call from in or near the edges of ponds, ditches, articifial water sources, or pools of slow moving rivers. The call consists of a long, slow, low-pitched trill</Calls>

<RangeAndHabitat>Rhinella horribilis is a very common nocturnal toad that may be found in many habitats ranging from near sea level to ~1,600m. They commonly occur in disturbed areas including agricultural areas and rural towns, and are more uncommonly encountered along forest edges and natural open areas.</RangeAndHabitat>

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</FrogSpecies>

<!--Bufonidae (Rhaebo) End-->

<!--Centrolenidae (Cochranella)-->

<FrogSpecies>

<SpeciesLatin>Cochranella euknemos</SpeciesLatin>

<SpeciesEnglish>Slope-snouted Glass Frog</SpeciesEnglish>

<Description>Cochranella euknemos is a small to moderate-sized frog (~24– 32mm, ~0.9– 1.3in). This species has a light green to emerald green dorsum with numerous neatly defined yellow to yellowishwhite spots scattered throughout. The snout has a strongly sloping profile. The pigmented section (white) of the parietal peritoneum is reduced, covering just the upper chest. The digestive organs are visible and are covered in a white visceral lining. Moderate webbing is found just between fingers III–IV, covering approximately one-third to half the distance to the tips of the fingers.</Description>

<SimilarSpecies>Cochranella euknemos could be confused with Sachatamia albomaculata and Teratohyla pulverata. Sachatamia albomaculata has a truncate snout profile and lacks a white lining on the digestive organs. Teratohyla pulverata completely lacks pigmentation in the parietal peritoneum and has moderate to extensive interdigital webbing between fingers II–III and III–IV.</SimilarSpecies>

<Calls>Males call from the upper surfaces of leaves within riparian vegetation. The call of Cochranella euknemos consists of one or two rapid high-pitched buzz-like notes, but occasionally as many as three to four notes might be emitted during a single advertisement call</Calls>

<RangeAndHabitat>In Costa Rica, this rare nocturnal species was just recently rediscovered after 25 years since its last encounter. Cochranella euknemos has only been found at a total of five sites in Costa Rica, all within cloud forests in the Central Volcanic Range, between ~1,150–1,500m.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Cochranella granulosa</SpeciesLatin>

<SpeciesEnglish>Granular Glass Frog</SpeciesEnglish>

<Description>Cochranella granulosa is a small to moderate-sized frog (~24– 32mm, ~0.9– 1.3in). The dorsal coloration is light green to emerald green and often has several dark spots, especially on the dorsal surface of the body. The dorsal skin has a granular texture. The pigmented section (white) of the parietal peritoneum is reduced, covering just the upper chest. The digestive organs are

visible, and are covered in a white visceral lining. The blue-green bones are particularly visible in the limbs.</Description>

<SimilarSpecies>Cochranella granulosa is quite different than any other Costa Rican anuran, so the likelihood of confusion should be minimal. One species that could possibly be confused with C. granulosa is Teratohyla spinosa. Teratohyla spinosa differs most from C. granulosa by lacking a white lining on the digestive organs.</SimilarSpecies>

<Calls>Males call from the upper surfaces of leaves on streamside vegetation, usually several meters above the stream. The call of Cochranella granulosa consists of a series of rapid highpitched pulsed trills “reet, reet, reet”, typically three notes, but occasionally as many as four to five notes might be emitted during a single advertisement call. Long pauses may occur between calls</Calls>

<RangeAndHabitat>This common nocturnal species inhabits the majority of the lowlands and foothills along the humid and even semi-humid forests of both the Caribbean and Pacific versants; principally being found from near sea level to ~1,500m.</RangeAndHabitat>

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</FrogSpecies>

<!--Centrolenidae (Cochranella) End-->

<!--Centrolenidae (Espandarana)-->

<FrogSpecies>

<SpeciesLatin>Espadarana prosoblepon</SpeciesLatin>

<SpeciesEnglish>Emerald Glass Frog</SpeciesEnglish>

<Description>Espadarana prosoblepon is a small to moderate-sized frog (~24– 31mm, ~0.9– 1.2in). This species has a light green to emerald green dorsum with numerous dark spots often scattered throughout. A partially pigmented (white) parietal peritoneum covers the upper two-thirds to threefourths of the venter, allowing only the lower sections of the intestines (lacking a white lining) to be seen. Adult males have an evident humeral projection on the upper arm, and the blue-green bones are particularly visible in the limbs.</Description>

<SimilarSpecies>Espadarana prosoblepon is quite unique among Costa Rican Glass Frogs, especially with the adult male individuals having their humeral projection, but it could be possible to confuse this species with Cochranella granulosa. Cochranella granulosa can easily be distinguished from E. prosoblepon due to having a white visceral lining.</SimilarSpecies>

<Calls>Males usually call from the upper surfaces of leaves on streamside vegetation, however they may also call from woody portions of plants (ex. stems and branches) and even rocks. The call of Espadarana prosoblepon is normally a rapid three-note series, “tik tik tik,” but occasionally the males can be heard emitting four or even five notes</Calls>

<RangeAndHabitat>In Costa Rica, this common nocturnal species is known to inhabit the lowlands and foothills of the humid and even semi-humid forests along both the Caribbean and Pacific versants; principally being found from near seal level to ~1,900m.</RangeAndHabitat>

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</FrogSpecies>

<!--Centrolenidae (Espandarana) End-->

<!--Centrolenidae (Hyalinobatrachium)-->

<FrogSpecies>

<SpeciesLatin>Hyalinobatrachium chirripoi</SpeciesLatin>

<SpeciesEnglish>Palm Glass Frog</SpeciesEnglish>

<Description>Hyalinobatrachium chirripoi is a small frog (~24– 29mm, ~0.9– 1.1in). The dorsum is light green with numerous fine yellow spots scattered throughout. The ventral surface of the body is transparent due to a lack of pigmentation in the parietal peritoneum. The pericardial sac lacks white

iridophores, thus a red heart is visible through the ventral skin. The bulbshaped liver and digestive organs are covered in a white visceral lining. Evident interdgital webbing is found between fingers II–III and III–IV, being moderate to extensive. The pale, yellowish bones are particularly visible in the limbs.</Description>

<SimilarSpecies>Hyalinobatrachium chirripoi could be confused with H. fleischmanni and H. colymbiphyllum. Hyalinobatrachium fleischmanni has a white heart visible through the ventral skin. Hyalinobatrachium colymbipyllum lacks evident webbing between fingers II–III.</SimilarSpecies>

<Calls>Males often call from the underside of smooth leaves overhanging streams; nonetheless, they can also be found calling from the upper surfaces at times. The advertisement call of Hyalinobatrachium chirripoi consists of a rapid highpitched trill, “brrrrrrrt”</Calls>

<RangeAndHabitat>Hyalinobatrachium chirripoi is principally known to inhabit humid forests in the lowlands and foothills in the southern and central Caribbean from ~50– 250m. This uncommon species was just recently rediscovered in Costa Rica after nearly 50 years since its last encounter within the country.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Hyalinobatrachium colymbiphyllum</SpeciesLatin>

<SpeciesEnglish>Bare-hearted Glass Frog</SpeciesEnglish>

<Description>Hyalinobatrachium colymbiphyllum is a small frog (~23– 29mm, ~0.9–1.1in). The dorsum is light green with numerous fine to moderate-sized yellow spots scattered throughout. The parietal peritoneum is not pigmented, nor is the pericardium, consequently the red heart is visible through the ventral skin. The bulb-shaped liver and digestive organs are covered in a white visceral lining. The most evident interdigital webbing is found between fingers III–IV, which is moderate. The pale yellow bones are particularly visible in the limbs.</Description>

<SimilarSpecies>Hyalinobatrachium coymbiphyllum could be confused with H. fleischmanni and H. chirripoi. Hylinobatrachium fleischmanni has a white heart visible through the ventral skin. Hyalinobatrachium chirripoi has nearly as extensive webbing between both fingers II–III and III–IV, whereas H. colymbiphyllum lacks webbing between fingures II and III.</SimilarSpecies>

<Calls>Males usually call from the undersides of smooth leaves overhanging streams. The advertisement call of H. colymbiphyllum consists of a somewhat quiet, high-pitched trill, “brrrrrrrt”</Calls>

<RangeAndHabitat>Hyalinobatrachium colymbiphyllum is fairly common in the humid forests of the lowlands and foothills of the central and southern Pacific, but uncommon to rare in the cloud forests of the Caribbean versant. The elevational range for H. colymbiphyllum is from near sea level to ~1,600m.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Hyalinobatrachium dianae</SpeciesLatin>

<SpeciesEnglish>Diane’s Bare-hearted Glass Frog</SpeciesEnglish>

<Description>Hyalinobatrachium dianae is a small frog (~27– 30mm, ~1.1– 1.2in). The dorsal coloration is uniform light green and lacks any light or dark spots. The ventral surface of the body is transparent due to a lack of pigmentation in the parietal peritoneum. The pericardial sac lacks white iridophores, resulting in a red heart being visible through the ventral skin. The bulb-shaped liver and digestive organs are covered in a white visceral lining. The skin of the dorsum is granular. The most

evident interdigital webbing is found between fingers III–IV, which is moderate. The iris is white, with fine darker pigmentation scattered throughout.</Description>

<SimilarSpecies>Hyalinobatrachium dianae is quite unique, but it could be confused with H. chirripoi, H. colymbiphyllum, and H. fleischmanni. The species that most closely resembles H. dianae is H. colymbiphyllum, but the latter has yellow dorsal spots, and a smoother dorsal skin texture. Hyalinobatrachium chirripoi is easily distinguished from H. dianae by its yellow dorsal spots and having extensive interdigital webbing between both fingers II–III and fingers III–IV. Hyalinobatrachium fleischmanni has a white heart and yellow spots on the dorsum.</SimilarSpecies>

<Calls>Males call from the underside of leaves on streamside vegetation; however, it is possible they also call from upper leaf surfaces. The call of Hyalinobatrachium dianae is a long metallic whistle with a weakly pulsed intensity</Calls>

<RangeAndHabitat>Hyalinobatrachium dianae is currently known to be endemic to Costa Rica, inhabiting the humid forests along the foothills of the central Caribbean region from roughly Limón to Río Frio. The known elevational range for H. dianae is ~400– 900m.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Hyalinobatrachium fleischmanni</SpeciesLatin>

<SpeciesEnglish>Fleischmann’s Glass Frog</SpeciesEnglish>

<Description>Hyalinobatrachium fleischmanni is a small frog (~22– 27mm, ~0.9– 1.1in). The dorsum is light green with numerous fine to moderate-sized yellow spots scattered throughout. The ventral surface of the body is transparent due to a lack of pigmentation in the parietal peritoneum. The pericardial sac is covered in white iridophores, thus a white heart is visible through the ventral skin. The bulbshaped liver and digestive organs are covered in a white visceral lining. The most evident interdigital webbing is found between fingers III–IV, which is moderate to extensive. The whitish-yellow bones are particularly evident in the limbs.</Description>

<SimilarSpecies>Because of similarity in overall dorsal coloration in some Hyalinobatrachium fleischmanni, it could be possible to confuse them with H. chirripoi, H. colymbiphyllum, and H. talamancae. But, these latter species all have a red heart visible through the ventral skin.</SimilarSpecies>

<Calls>Males usually call from the undersurfaces of leaves on streamside vegetation. The call of Hyalinobatrachium fleischmanni is a single short high-pitched rising whistle, “shweet”</Calls>

<RangeAndHabitat>Hyalinobatrachium fleischmanni is common throughout the humid forests of the Caribbean lowlands and foothills, the Central Valley, and sections along the ridges of Tilarán and Guanacaste. This species is also found, but less commonly, in the valleys of the Río General and Río Coto Brus on the Pacific versant. The known elevational range for H. fleischmanni is from near sea level to ~1,900m.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Hyalinobatrachium talamancae</SpeciesLatin>

<SpeciesEnglish>Talamanca Glass Frog</SpeciesEnglish>

<Description>Hyalinobatrachium talamancae is a small frog (~22– 27mm, ~0.9– 1.1in). The dorsum is light green with numerous fine to moderate-sized yellow spots scattered throughout. In the center of the dorsum there is a distinct green mid-dorsal longitudinal stripe, which runs from the base of the head to near the anal vent. The ventral surface of the body is transparent due to a lack of pigmentation in the parietal peritoneum. The pericardial sac lacks white iridophores, thus a red heart is visible through the

ventral skin. The bulbshaped liver and digestive organs are covered in a white visceral lining. The pale, yellowish white bones are particularly visible in the limbs.</Description>

<SimilarSpecies>Due to the presence of a distinct green mid-dorsal line, Hyalinobatrachium talamancae is quite unique, but nonetheless this species could possibly be confused with the H. vireovittatum. Hyalinobatrachium talamancae is actually quite similar to H. vireovittatum in overall appearance, but these two species are known to be allopatric; H. talamancae is found on the Caribbean versant, whereas H. vireovittatum is only known from the central–southern Pacific foothills of Costa Rica.</SimilarSpecies>

<Calls>Males usually call from the undersurfaces of leaves overhanging small streams and seepages. The call of Hyalinobatrachium talamancae is a single long whistle-like note "shhhhhhhhhr"</Calls>

<RangeAndHabitat>Hyalinobatrachium talamancae is only known to inhabit humid forests in the foothills along the Caribbean versant, at elevations ranging from ~400– 1,500m. This uncommon species was just recently rediscovered in Costa Rica after nearly 50 years since its last encounter within the country.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Hyalinobatrachium valerioi</SpeciesLatin>

<SpeciesEnglish>Reticulated Glass Frog</SpeciesEnglish>

<Description>Hyalinobatrachium valerioi is a small frog (~22– 26mm, ~0.9– 1.0in). The dorsal surface is translucent pale yellow with a contrasting green reticulation. The ventral surface of the body is transparent due to a lack of pigmentation in the parietal peritoneum. The pericardial sac is partially or fully pigmented by white iridophores, thus a fully white heart or one that has red patches is visible through the ventral skin. The bulb-shaped liver and digestive organs are covered in a white visceral lining. The bones are pale in color and are particularly visible in the limbs.</Description>

<SimilarSpecies>Hyalinobatrachium valerioi is quite unique and should not be confused with any frog species within Costa Rica.</SimilarSpecies>

<Calls>Males call from the surfaces of leaves on streamside vegetation. The advertisement call of Hyalinobatrachium valerioi is a single short whistle-like note "peep"</Calls>

<RangeAndHabitat>Hyalinobatrachium valerioi can be found along the lowlands and foothills on both the Caribbean and Pacific versants in a variety of habitats including both forests as well as disturbed areas. On the Caribbean versant H. valerioi is known from roughly Arenal Lake south, whereas on the Pacific slopes this species in known from roughly Río Tarcoles south. This relatively common species is principally known to inhabit humid forests below ~1,000m.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Hyalinobatrachium vireovittatum</SpeciesLatin>

<SpeciesEnglish>Striped Glass Frog</SpeciesEnglish>

<Description>Hyalinobatrachium vireovittatum is a small frog (~21– 25mm, ~0.8– 1.0in). The dorsum is lime-green with moderate to fine canary yellow spots. Running through the center of the back, from the base of the head to near the anal vent, is a distinct green mid-dorsal stripe, which is often bordered on both sides by uniform yellow para-vertebral lines. The ventral surface of the body is transparent due to a lack of pigmentation in the parietal peritoneum. The pericardial sac lacks white iridophores, thus a red heart is visible through the ventral skin. The bulb-shaped liver and digestive organs

are covered in a white visceral lining. The pale yellowish bones are particularly visible in the limbs.</Description>

<SimilarSpecies>Hyalinobatrachium vireovittatum is actually quite similar to H. talamancae in overall appearance. However, H. vireovittatum usually has yellow para-vertebral lines. Perhaps more importantly, these two species are known to be allopatric; H. talamancae is found on the Caribbean versant, whereas H. vireovittatum is only known from the central–southern Pacific foothills of Costa Rica.</SimilarSpecies>

<Calls>Males usually call from the undersurfaces of leaves overhanging small streams and seepages. The advertisement call of Hyalinobatrachium vireovittatum is a long whistle-like note "shhhhhhhr", very similar to that of H. talamancae</Calls>

<RangeAndHabitat>Hyalinobatrachium vireovittatum is currently only known to inhabit the coastal foothills of the central-southern Pacific, from roughly Parrita to Palmar Norte. This uncommon to rare nocturnal species has been found in a narrow altitudinal band from ~250–1,000m.</RangeAndHabitat>

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</FrogSpecies>

<!--Centrolenidae (Hyalinobatrachium) End-->

<!--Centrolenidae (Sachatamia)-->

<FrogSpecies>

<SpeciesLatin>Sachatamia albomaculata</SpeciesLatin>

<SpeciesEnglish>Cascade Glass Frog</SpeciesEnglish>

<Description>Sachatamia albomaculata is a small to moderate-sized frog (~24– 32mm, ~0.9– 1.3in). This species has a light green to emerald green dorsum with yellow spots scattered throughout. The dorsal spotting of this species can vary among individuals, and especially between the populations on the Caribbean and Pacific versants; Pacific populations have finer and more neatly defined spots, whereas Caribbean populations tend to have larger and more diffuse dorsal spotting. A partiallypigmented white parietal peritoneum covers one-half to two-thirds of the ventral surface. In the lower section of the abdomen, the viscera are visible and lack a white visceral lining. Moderate webbing is found between fingers III–IV. The Snout of S. albomaculata is truncate in profile. The green bones are particularly visible in the limbs</Description>

<SimilarSpecies>It could be possible to confuse Sachatamia albomaculata with Cochranella euknemos or Teratohyla pulverata. Cochranella euknemos has a strongly sloping snout profile and a white lining of the digestive organs. Teratohyla pulverata lacks pigmentation in the parietal peritoneum, has extensive webbing between fingers II–III and III–IV, and has a sloping snout profile.</SimilarSpecies>

<Calls>Males call from the upper surfaces of leaves, as well as from branches and rocks in or near streams and cascades. The advertisement call consists of a rapid, high-pitched single note, "tik" often repeated with a second or two pause between notes</Calls>

<RangeAndHabitat>Sachatamia albomaculata occurs in humid and semi-humid forests along lowlands and foothills of the Caribbean and Pacific versants. This relatively common species is found from near sea level to ~1,450m.</RangeAndHabitat>

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</FrogSpecies>

<!--Centrolenidae (Sachatamia) End-->

<!--Centrolenidae (Teratohyla)-->

<FrogSpecies>

<SpeciesLatin>Teratohyla pulverata</SpeciesLatin>

<SpeciesEnglish>Dusty Glass Frog</SpeciesEnglish>
<Description>Teratohyla pulverata is a small to moderatesized frog (~24– 31mm, ~0.9–1.2in). The dorsum is relatively smooth, and light green to emerald green, with numerous fine to moderatesized white spots scattered throughout. The parietal peritoneum lacks pigmentation and is transparent. The liver, heart and digestive organs are covered with a white visceral lining. The snout is sloping in profile. This species has a slight white fleshy fringe along the outer edges of the forearm and lower leg. Evident webbing is found between fingers II–III and III–IV, which is moderate to extensive. The pale green bones are particularly visible in the limbs.</Description>
<SimilarSpecies>This species is unique among Costa Rican Glass Frogs, but nonetheless could potentially be confused with Cochranella euknemos. Cochranella euknemos has a sloping snout in profile, similar to that of T. pulverata, but has a partially pigmented parietal peritoneum obscuring the anterior internal organs, and lacks evident webbing between fingers II–III.</SimilarSpecies>
<Calls>Males call from the upper surfaces of leaves on streamside vegetation, often several meters above the stream. The advertisement call of Teratohyla pulverata is a quick high-pitched "tik," which is often repeated in a series of three notes with a brief pause between each note</Calls>
<RangeAndHabitat>Teratohyla pulverata inhabits the humid forests along most of the lowlands and foothills of both the Caribbean and the Pacific versants. The elevational range for this common species is from near sea level to ~1,000m.</RangeAndHabitat>
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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Teratohyla spinosa</SpeciesLatin>
<SpeciesEnglish>Dwarf Glass Frog</SpeciesEnglish>
<Description>Teratohyla spinosa is small frog (~18– 22mm, ~0.7– 0.9in). This species is not only the smallest Glass Frog in Costa Rica, but also Central America. The dorsum is uniform green, lacking dark or light spots. A partially white-pigmented parietal peritoneum covers approximately half to twothirds of the ventral surface of the body. Teratohyla spinosa lacks a white lining of the digestive organs, and they are partially visible through the lower abdomen. Teratohyla spinosa is the only species in Costa Rica that has a protruding prepollical spine at the base of finger I, which is often visible upon close inspection with a hand lens. The green bones are particularly visible in the limbs</Description>
<SimilarSpecies>Other species of Glass Frogs that could possibly be confused with Teratohyla spinosa are Cochranella granulosa, Espadarana prosoblepon and Sachatamia ilex, but these latter species lack a prepollical spine structure at the base of finger I. Further, C. granulosa has raised granules on the dorsum that often have a bluish hue, E. prosoblepon usually has dark dorsal spotting, and S. ilex is much larger, and has a silver-white iris with a strongly contrasting dark reticulation.</SimilarSpecies>
<Calls>The advertisement call of Teratohyla spinosa is a fast high-pitched trill, typically consisting of one or two distinctly pulsed notes, "treet" or "treet, treet". Males call from the upper surfaces of vegetation bordering small streams</Calls>
<RangeAndHabitat>Teratohyla spinosa is found in the humid forests along the lowlands and foothills of much of the Caribbean versant, from near sea level to ~900m.</RangeAndHabitat>
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</FrogSpecies>
<!--Centrolenidae (Teratohyla) End-->

<!--Craugastoridae (Craugastor)-->
<FrogSpecies>
<SpeciesLatin>Craugastor andi</SpeciesLatin>

<SpeciesEnglish>Starrett's Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor andi is a medium to large-sized frog (~40– 55mm, ~1.6– 2.2in males; ~65– 80mm, ~2.6– 3.2in females), with a slim build, tapered snout and long limbs. The skin is smooth. The eyes are large, with horizontal pupils, and light colored irises with a darker horizontal band. Tympanic membranes (larger in males) are visible below a supratympanic fold. Dorsal coloration is brown, often with a pale vertebral stripe. Bright yellow spots occur on the groin and posterior thigh. Contrasting dark and white markings occur on the lips and onto the shoulder. The venter is cream anterior and yellow posteriorly, with dark mottling. The throat is dark, but the absence of pigment medially creates a pale line. Fingers and toes have expanded emarginate terminal pads. Fingers lack webbing, and toes have moderate webbing. Males have brown nuptial pads and a small, internal vocal sac.</Description>

<SimilarSpecies>Craugastor andi may be confused with other Craugastor species. Craugastor cuaquero is most similar, but is smaller in size and has very limited toe webbing. Craugastor fitzingeri has a slightly rougher texture of the dorsal skin, smaller pale spots on the posterior thighs, and lacks emarginate pads on the digits.</SimilarSpecies>

<Calls>Males are known to call from streamside habitats. The call is described as a single note, low-pitched "glug" produced at long intervals.</Calls>

<RangeAndHabitat>Craugastor andi is an uncommon nocturnal frog found in riparian habitats. Outside of the breeding season, they are found in streamside vegetation and forest canopy at elevations ranging from ~900 to 1,400m. Historically this species had a limited distribution and like many other species, experienced severe declines in the late 1980s and is now rare, if not extinct. Encounters with this species should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor angelicus</SpeciesLatin>

<SpeciesEnglish>Angel Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor angelicus is a medium to large-sized frog (~26– 46mm, ~1– 1.8in males; ~38– 75mm, ~1.5– 3in females) with a robust build, and rounded snout. The skin is smooth to slightly granular. The eyes are large, with horizontal pupils, and light colored irises with a darker horizontal band. Tympanic membranes (larger and round in males vs. smaller and oval in females) are visible below a supratympanic fold. Dorsal coloration is brown to gray, usually with dark spots. The posterior thighs are darkly pigmented, with pale markings present. The venter ranges from pale yellow to yellowish orange or red. The throat varies in extent of pigmentation, but lacks the pale median line. Fingers and toes have slightly expanded terminal pads. Fingers lack webbing, and toes have very limited (basal) webbing. Males have pale nuptial pads, but lack vocal slits.</Description>

<SimilarSpecies>Craugastor angelicus may be confused with closely related Craugastor species. Craugastor escoces is most similar, but differs in having wider terminal finger pads. Craugastor fleischmanni differs in having slight terminal pads on the digits and lacking the bright ventral colors of C. angelicus.</SimilarSpecies>

<Calls>The advertisement call for this species is unknown.</Calls>

<RangeAndHabitat>Craugastor angelicus is a formerly common nocturnal frog that occurred near streams in forests ranging in elevation from ~650 to 1,600m. Individuals forage and reproduce on steep streamside banks. This is another species that has disappeared from pristine habitat and is now very rare. Encounters should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor bransfordii</SpeciesLatin>
<SpeciesEnglish>Bransford's Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor bransfordii is a tiny to small (~18– 25mm, ~0.7– 1in), but robust frog. The dorsal coloration is extremely variable, ranging from tan to dark brown, with a mixture of spots, bands, or irregular markings in assorted earthy tones. On the groin, thighs, and ventral surface of the lower leg, there is often a reddishorange suffusion. The dorsal skin is granular, with some specimens also having numerous longitudinal ridges. The eyes have horizontal pupils, with a gold to copper iris. The ventral surfaces are light tan to gray with numerous lighter markings, especially on the throat. The hands and feet lack both expanded discs on the tips of the digits, and interdigital webbing. Males have an enlarged nuptial pad at the base of finger I. The thenar and palmar tubercles are either nearly equal in size, or the palmar tubercle is slightly larger. The ventral surfaces of the hands and feet have numerous large projecting tubercles. The tympanic membrane is evident, and slightly larger on males.</Description>
<SimilarSpecies>Craugastor bransfordii might be confused with C. underwoodi and C. polyptychus. Craugastor underwoodi is slightly larger and typically has smoother, less projecting tubercles on the ventral surfaces of the hands and feet. Craugastor polyptychus is slightly larger, and males lack nuptial pads.</SimilarSpecies>
<Calls>The advertisement call of Craugastor bransfordii consists of a quick chirp-like squeak.</Calls>
<RangeAndHabitat>Craugastor bransfordii occurs throughout much of the lowlands and foothills of the northern and central Caribbean, from ~50 to 900m. This common diurnal species can be found in a variety of habitats from old-growth forest to young secondary forest. Craugastor bransfordii is terrestrial, and is often seen hopping among the leaf litter on the forest floor.</RangeAndHabitat>
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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor catalinae</SpeciesLatin>
<SpeciesEnglish>Karen's Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor catalinae is a medium to largesized frog (~30– 45mm, ~1.2– 1.8in males; ~45– 75mm, ~1.2– 3in females), with a robust build, and rounded snout. The skin is smooth to slightly granular. The eyes are large, with horizontal pupils, and light colored irises with a darker horizontal band. Tympanic membranes (larger in males) are visible below a slight supratympanic fold. Dorsal coloration is brown, greenish brown, or gray, usually with dark spots. The posterior thighs are dark with small yellow spots. The venter is white to cream colored. Fingers and toes have slightly expanded terminal pads. Fingers lack webbing, and finger I is longer than finger II. Toes have a lateral fringe and moderate webbing, a tarsal fold also occurs. Males have nuptial pads, and a vocal sac.</Description>
<SimilarSpecies>Craugastor catalinae may be confused with C. taurus, C. fleischmanni, C. obesus, and C. rhyacobatrachus. Both C. fleischmanni and C. taurus have smaller discs on the digits, and C. taurus is restricted to low elevations. Both C. obesus and C. rhyacobatrachus have larger discs on the digits and more toe webbing.</SimilarSpecies>
<Calls>The advertisement call of Craugastor catalinae is unknown.</Calls>
<RangeAndHabitat>Craugastor catalinae is found on the Pacific versant at elevations ranging from ~1,200 to 1,800m. This nocturnal species is associated with riparian habitats and is usually found on rocks in the stream or streamside vegetation. Craugastor catalinae was never widespread, but was locally common, prior to declines. They have now disappeared from much of their known range. Any encounters with this species should be carefully documented.</RangeAndHabitat>
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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor crassidigitus</SpeciesLatin>
<SpeciesEnglish>Thick-fingered Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor crassidigitus is a medium-sized frog (~20– 50mm; ~0.8– 2in), with a slim build, tapered snout and long legs. The dorsal skin is nearly smooth to slightly granular with scattered larger tubercles; ventral skin is smooth. The eyes are large, with horizontal pupils, and light colored irises with a darker horizontal band. Tympanic membranes are large (approx. the size of the eye in males) and readily visible below supratympanic folds. Males have nuptial pads and a small, internal vocal sac. Fingers and toes have expanded terminal pads. Fingers lack webbing, and toes have only limited webbing. Dorsal coloration is extremely variable, but usually a shade of brown or gray with scattered darker (occasionally green) blotches and/or a light mid-dorsal stripe. Dark markings occur on or below the supratympanic fold, and dark bars occur on the limbs dorsally. The posterior thigh is uniform in color (brown, orange, or red). The venter is white, but may have scattered dark spots.</Description>
<SimilarSpecies>Craugastor crassidigitus is most likely to be confused with C. fitzingeri, however the latter species has large, light spots on the posterior thigh, minimal toe webbing, and a white stripe on the throat. Other similar species include C. talamancae, and C. mimus. However, these both have a dark eye mask that may extend onto the body, and C. talamancae has a light lip stripe.</SimilarSpecies>
<Calls>Males call at night from the understory vegetation. They produce a “squeak” or “squawk” like call ranging from a single to several notes</Calls>
<RangeAndHabitat>A very common species occurring in nearly all moist to wet habitats (absent from dry forests of Guanacaste) on both slopes from near sea level to ~2,000m. They are usually found while active (night) on low vegetation, but may also be found diurnally in leaf litter.</RangeAndHabitat>
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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor cuaquero</SpeciesLatin>
<SpeciesEnglish>Quaker Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor cuaquero is a medium-sized frog (~33– 48mm, ~1.3– 1.9in female). The skin is smooth with a few scattered low, rounded tubercles and a supraocular tubercle. The dorsal coloration is dark brown with lighter brown limbs. A supratympanic fold, which is darkly colored on the inferior margin extends from the eye over the tympanic membrane and down to the shoulder. The posterior thighs are brown with yellowish cream spots or vertical bars. The venter is smooth and pale in color, with a pink wash in the groin. The throat is dark with a white median stripe. The eyes are large, with horizontal pupils, and light colored irises with a darker horizontal band. The digits have enlarged terminal discs. Fingers lack webbing, and the toes have limited webbing.</Description>
<SimilarSpecies>Craugastor cuaquero is similar to C. andi, C. fitzingeri, C. rayo, C. talamancae, and C. crassidigitus. Both C. andi and C. fitzingeri differ in having substantial toe webbing. Craugastor crassidigitus, C. rayo and C. talamancae all differ in having a uniformly colored posterior thigh, and C. crassidigitus has slightly more toe webbing and lacks the pink coloration in the groin.</SimilarSpecies>
<Calls>The advertisement call of Craugastor cuaquero is unknown.</Calls>
<RangeAndHabitat>Craugastor cuaquero is endemic to Costa Rica, and only known to inhabit lower montane cloud forests near Monteverde at elevations of ~1,500 to 1,650m. This species is only known from two female specimens both found at night on low vegetation. Any encounters with this species should be carefully documented.</RangeAndHabitat>
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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor escoces</SpeciesLatin>
<SpeciesEnglish>Scott's Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor escoces is a medium-sized frog (~26– 46mm, ~1– 1.8in males; ~38– 72mm, ~1.5– 2.8in females) with a robust build, and rounded snout. The skin is smooth to slightly granular. The eyes are large, with horizontal pupils, and gold colored irises with a darker lower half. Tympanic membranes (larger and round in males vs smaller and oval in females) are visible below a supratympanic fold. Dorsal coloration is dark olive, and the posterior thigh is uniformly colored. The venter is red, with dark mottling. Fingers and toes have expanded terminal pads. The fingers lack webbing, and toes have very limited webbing. Males have nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Craugastor escoces is most likely to be confused with C angelicus and C. fleischmanni. Craugastor angelicus differs in lacking vocal slits, having minimally expanded terminal pads on the digits, and the ventral color is subtly different being yellow, orange or orangish-red. Craugastor fleischmanni differs in having a more granular dorsum, pale colors (gray dorsally and yellow ventrally), marked posterior thigh, more toe webbing, and minimally expanded terminal pads on the digits.</SimilarSpecies>
<Calls>The advertisement call of Craugastor escoces is unknown.</Calls>
<RangeAndHabitat>Craugastor escoces is a formerly common frog found in the premontane and lower montane forests of the Central Volcanic Cordillera at elevations ranging from ~1,100 to 2,100m. They are a riparian species usually found foraging along stream banks. This is another amphibian species that disappeared from intact habitat and was considered extinct, but was recently rediscovered. Any encounter with this species should be carefully documented.</RangeAndHabitat>
<PageNumber>86</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor fitzingeri</SpeciesLatin>
<SpeciesEnglish>Fitzinger's Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor fitzingeri is a medium-sized frog (~25– 55mm; ~0.9– 2.1in), with a slim build, tapered snout and long legs. The skin is slightly granular with scattered tubercles dorsally; ventral skin is smooth. The eyes are large, with horizontal pupils, and light colored irises with a darker horizontal band. Tympanic membranes are large (~equal to the size of the eye in males, smaller in females) and readily visible below supratympanic folds that curve down towards the shoulder. Males have brown nuptial pads and a small, internal vocal sac. Fingers and toes have expanded terminal pads. Fingers lack webbing, and toes have limited webbing. Dorsal coloration is extremely variable, but usually a shade of brown or gray with scattered darker blotches and often a pale mid-dorsal stripe. The supratympanic fold is darkly pigmented, and dark bars occur on the limbs dorsally. The posterior thigh is dark with distinct light spots. The venter is white with blotches of diffuse dark pigment. A pale median stripe is present on the throat of most individuals.</Description>
<SimilarSpecies>Craugastor fitzingeri is most likely to be confused with C. crassidigitus. However the latter species differs in lacking both the large, light spots on the posterior thigh, and a white stripe on the throat, as well as having more toe webbing. Craugastor ranoides is also similar, but differs in being more granular and having yellow on the posterior half of the venter and on the ventral surface of the thighs.</SimilarSpecies>
<Calls>Males call from leaf litter or low vegetation producing a series of short, harsh notes in quick succession, sounding like "chek, chek, chek, chek…"</Calls>

<RangeAndHabitat>A very common species occurring in nearly all moist/wet habitats on both slopes from near sea level to ~1,500m. They are usually found while active (night) on the forest floor, or on low vegetation.</RangeAndHabitat>
<PageNumber>87</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor fleischmanni</SpeciesLatin>
<SpeciesEnglish>Fleischmann's Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor fleischmanni is a medium-sized frog (~29– 47mm, ~1.1– 1.9in males; ~38– 75mm, ~1.5– 3in females). They have a robust build, wide head, and rounded snout. The dorsal skin is variable in texture, ranging from smooth to granular. The eyes have horizontal pupils, and brass colored irises with a darker lower half. Tympanic membranes (larger and round in males vs smaller and oval in females) are visible below a supratympanic fold. Dorsal coloration is gray to dark brown and may have scattered black spots. The posterior thigh is blotched or mottled. The venter is pale yellow, with dark mottling. Fingers and toes have only slightly expanded terminal pads. The fingers lack webbing, and toes have very limited to moderate webbing, and lateral fringes. A distinct tarsal fold is present. Males have nuptial pads and a subgular vocal sac.</Description>
<SimilarSpecies>Craugastor fleischmanni is most likely to be confused with C angelicus and C. escoces. Craugastor angelicus differs in having larger terminal pads on the digits (they are barely wider than toes on C. fleischmanni), a yellow, orange or orangish-red venter, and lacking vocal slits. Craugastor escoces differs in having a smoother dorsum, a bright red venter, uniformly colored posterior thigh, more toe webbing, and larger terminal pads on the digits.</SimilarSpecies>
<Calls>The advertisement call of Craugastor fleischmanni is unknown.</Calls>
<RangeAndHabitat>Craugastor fleischmanni is a formerly common frog found in the premontane and lower montane forests of the Central Volcanic Range and western Talamancas at elevations ranging from ~1,050 to 2,500m. They are a riparian species, usually found foraging along stream banks. This species has disappeared from intact habitat and is now considered critically endangered.</RangeAndHabitat>
<PageNumber>88</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor gabbi</SpeciesLatin>
<SpeciesEnglish>Gabb's Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor gabbi is a small-sized frog (~14– 22mm, ~0.6– 0.8in). The skin is relatively granular. The head is smooth, with a short snout. The eyes are large, with a horizontal pupil and a copper or brassy iris. Tympanic membranes are readily visible below a darkly pigmented supratympanic stripe/ridge. The variable dorsal coloration is usually brown or gray. Darker blotches are often present on the limbs, and a pale middorsal stripe may occur. The venter is cream with dark pigment reaching the midline. The fingers are unwebbed, but the toes have basal webbing. Distinct tubercles occur on the digits, feet and hands; including a palmar tubercle that is distinctly larger than the thenar tubercle. Males lack both vocal sacs and nuptial pads.</Description>
<SimilarSpecies>Craugastor gabbi appears similar to other small Craugastor species. Nonetheless C. underwoodi differs in having palmar and thenar tubercles of nearly equal size and males have nuptial pads. Craugastor podiciferus differs in having a distinct heel tubercle (absent on C. gabbi). Craugastor stejnegerianus is most similar but differs in usually lacking the ventral dark pigment reaching the midline, and occurring at lower elevations. Other similar species differ in occurring on the Atlantic slope (C. bransfordii, C. persimilis, and C. polyptychus).</SimilarSpecies>

<Calls>The advertisement call of Craugastor gabbi is a short, high-pitched squeak</Calls>

<RangeAndHabitat>Craugastor gabbi is locally abundant occurring on the Pacific versant of the eastern Talamancas at elevations of ~1,100 to 1,300m. They can be found in premontane forests as well as disturbed sites. They are usually found in the in the day hopping in the leaf litter, but similar to C. stejnegerianus they may also be active at night.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor gollmeri</SpeciesLatin>

<SpeciesEnglish>Gollmer's Masked Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor gollmeri is a moderate-sized (~25– 55mm, ~1– 2.2in), and robust frog. The dorsal coloration typically ranges from gray, tan or reddish orange, often having a fine light middorsal stripe and numerous darker irregular bands, especially on the arms and legs. A dark brown to black mask, extends from the snout, below the canthal ridge, upper eyelid, supratympanic fold, and diagonally downward onto the anterior flank. The dorsal skin is smooth to weakly granular, with some slightly larger rounded to conical tubercles scattered throughout, especially on the arms and legs, on the upper eyelids, and on each of the shoulders. The eyes have a horizontal pupil, with the upper half of the iris being copper to red, while the lower half is dark, principally black. The ventral surfaces of the body are cream to light tan, with the throat often being light gray. The hands and feet lack both expanded terminal discs, and evident interdigital webbing. On the heel there are typically one or two evident tubercles.</Description>

<SimilarSpecies>Craugastor gollmeri might be confused with C. noblei and C. mimus. Craugastor mimus has weak to moderate interdigital webbing on the feet, and fleshy fringes on the margins of the toes. Craugastor noblei has expanded discs on the tips of fingers III and IV.</SimilarSpecies>

<Calls>The advertisement call of Craugastor gollmeri is a fast series of ~13 soft, short "ah" notes.</Calls>

<RangeAndHabitat>Craugastor gollmeri occurs throughout much of the Caribbean foothills, at elevations ranging from near sea level to ~1,500m, but is most commonly encountered in premontane forests (>500m). This uncommon species is most often observed during the day, hopping among the leaf litter on the forest floor, or at times at night on low vegetation.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor gulosus</SpeciesLatin>

<SpeciesEnglish>Big-throated Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor gulosus is a medium to largesized frog (estimated as ~40– 60mm, ~1.6– 2.4in males; ~72– 103mm, ~2.8– 4.1in females). These frogs have a very large head and a smooth dorsum. Cranial crests are present, as are supratympanic folds that curve down to the shoulder. Tympanic membranes are visible. Dorsal coloration is brown to dark brown, with a dark mark along the supratympanic fold, and dark spots on the tympanic membrane, under the eye, and occasionally a few on the dorsum. The eyes are large and have horizontal pupils and gold irises with heavy, dark reticulations. The venter is pale yellow with brown mottling. The arms are relatively short and stocky. There is no webbing on the hands or feet. The fingers lack expanded terminal pads, whereas those on the toes are slightly expanded. Males lack nuptial pads.</Description>

<SimilarSpecies>Craugastor gulosus may be confused with the other broad-headed frogs in Costa Rica, including C. megacephalus, C. rugosus, and Strabomantis bufoniformis. Both Craugastor

species differ in having distinct dorsal folds extending posteriorly from the supratympanic fold. Craugastor megacephalus differs further in also having folds above the pelvis, whereas C. rugosus differs further in having a posterior thigh marked with red and black blotches (white and black in juveniles). Strabomantis bufoniformis differs in having a granular or tuberculate dorsum and toe webbing.</SimilarSpecies>

<Calls>The advertisement call of Craugastor gulosus is unknown.</Calls>

<RangeAndHabitat>Craugastor gulosus is a rare frog that may be found in premontane and lower montane forests of the Talamancas at elevations ranging from ~1,000 to 1,900m. They are terrestrial species found on the forest floor. Craugastor gulosus is a poorly known species in Costa Rica, and any encounters should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor megacephalus</SpeciesLatin>

<SpeciesEnglish>Big-headed Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor megacephalus is a moderate to large-sized (~30– 43mm, ~1.2–1.7in males; ~50– 70 mm, ~2– 2.8in females), and robust frog. The dorsal coloration, ranges from tannish gray to reddish orange, often having a fine light middorsal stripe and numerous darker irregular bands, especially on the arms and legs. In the center of the back, between the base of the head and sacrum, there is a pair of dermal ridges that form an hourglass pattern. There is a black supratympanic line. The dorsal skin is granular, with some slightly larger tubercles scattered throughout, especially on the arms and legs. On the upper eyelids there are a group of larger rounded to conical tubercles. The eyes have a horizontal pupil, with a golden yellow to goldish-orange iris having a dark reticulation. The ventral surface of the body and legs is dark with numerous large light spots or irregular markings; the throat is similar in color to the ventral surface of the body, but finely speckled. The hands and feet lack both webbing and greatly expanded terminal discs on the digits.</Description>

<SimilarSpecies>Craugastor megacephalus, with its evident hourglass-shaped dorsal ridges and patterned ventral surface, is very distinct. Craugastor gulosus and C. rugosus are similar is shape and habit, but both lack the patterned venter, and C. gulosus lacks the dorsal folds, whereas C. rugosus has red and black posterior thighs.</SimilarSpecies>

<Calls>The advertisement call of Craugastor megacephalus is unknown.</Calls>

<RangeAndHabitat>Craugastor megacephalus inhabits most of the Caribbean lowlands and foothills, from near sea level to ~1,200m. This relatively common nocturnal species is principally found in old-growth forest and secondary forest. Craugastor megacephalus is terrestrial, and can often be observed at night sitting on the forest floor.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor melanostictus</SpeciesLatin>

<SpeciesEnglish>Black-spotted Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor melanostictus is a mediumsized frog (~35– 55mm; ~1.4–2.2in). There are scattered tubercles dorsally, whereas the ventral skin is slightly granular. The eyes are large, with horizontal pupils, and reddish or copper/red irises. Distinct supraocular tubercles are present. Tympanic membranes are obscure, but visible below supratympanic folds. Dorsal coloration is variable, ranging from brown, green or gray. Dark markings radiate from the eye to the snout, lip and along the supratympanic fold. Dark bars alternate with lighter colors on the legs. Red, magenta, orange or yellow occurs on groin and on thighs between dark bars. The venter is pale in color, but may be heavily suffused

with dark markings. Fingers and toes lack webbing, and have expanded terminal pads. Males have light colored nuptial pads and a subgular vocal sac.</Description>

<SimilarSpecies>Craugastor melanostictus is most likely to be confused with Craugastor or Pristimantis species. Craugastor crassidigitus, C. fitzingeri and C. andi are all similar in size, and have dark markings on the face, but all lack the supraocular tubercles. Craugastor escoces and C. fleischmanni are also similar, but both differ in having brightly colored venters (red, or yellow, respectively). Pristimantis cruentus has supraorbital tubercles, but differs in having toe V longer than toe III.</SimilarSpecies>

<Calls>Males call after heavy rains from low vegetation producing a musical, whistling "phooot" repeated in a group of quick notes</Calls>

<RangeAndHabitat>Craugastor melanostictus is an uncommon species occurring mostly in mature forests of the Cordilleras from ~1,150 to 2,700m. They are usually found while active (night) on low vegetation.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor mimus</SpeciesLatin>

<SpeciesEnglish>Mimic Masked Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor mimus is a moderate-sized (~30– 60mm, ~1.2– 2.4in), and robust frog. The dorsal coloration ranges from tannish gray to reddish orange, often having a fine light middorsal stripe and numerous darker irregular bands, especially on the arms and legs. A dark brown to black mask runs from the tip of the snout, below the canthal ridge, upper eyelid, supratympanic fold, and diagonally downward onto the anterior half of the flank. The dorsal skin is smooth to weakly granular, with a few small rounded tubercles scattered throughout. The eyes have a horizontally elliptical pupil, with the upper half of the iris being golden yellowish gray to golden orange, while the lower half is dark. The ventral surfaces of the body are cream to light tan, and the throat often has a slight gray hue. The digits lack expanded terminal discs, and weak to moderate webbing is only present on the feet. The edges of the toes have weak fleshy fringes.</Description>

<SimilarSpecies>Craugastor mimus might be confused with C. gollmeri and C. noblei. Craugastor mimus has weak to moderate interdigital webbing on the feet, and fleshy fringes on the margins of the toes, whereas both C. gollmeri and C. noblei lack any evident webbing on the hands or feet.</SimilarSpecies>

<Calls>The advertisement call of Craugastor mimus is unknown.</Calls>

<RangeAndHabitat>Craugastor mimus has been found at scattered locations throughout most of the Caribbean lowlands and foothills, from near sea level to ~1,000m. This relatively common species is mostly diurnal, and is principally found in old-growth forest and secondary forest. Craugastor mimus is most often observed during the day, hopping among the leaf litter on the forest floor, or at night on the low vegetation.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor noblei</SpeciesLatin>

<SpeciesEnglish>Noble's Masked Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor noblei is a moderate to largesized (~30– 70mm, ~1.2– 2.8in), and robust frog. The dorsal coloration typically ranges from tannish gray to reddish orange, often having a fine light middorsal stripe and numerous darker irregular bands, especially on the arms and legs. There is often a dark "X" pattern on the dorsum. A dark mask extends from the tip of the snout onto the anterior

flank. The dark mask on C. noblei is often weaker than those found on C. gollmeri and C. mimus. The dorsal skin is smooth to weakly granular. The eyes have a horizontal pupil, with the upper half of the iris is golden yellow, whereas the lower half is orangish-red; there is a dark reticulation throughout. The ventral surfaces are creamish white (head/body), or reddish orange (limbs). The hands and feet lack evident interdigital webbing. The terminal discs on finger fingers III and IV are noticeably wider than those on the other digits. The groin, anterior thigh, and posterior dorsal thigh typically have a reddish-orange coloration.</Description>

<SimilarSpecies>Craugastor noblei may be confused with C. gollmeri and C. mimus. However, they both lack the expanded discs on the tips of fingers III and IV that are present in C. noblei.</SimilarSpecies>

<Calls>Males have been observed calling from hidden locations on the forest floor near sunset. The advertisement call consists of two loud rapidly repeated notes in long series of up to 400 distinct calls.</Calls>

<RangeAndHabitat>Craugastor noblei inhabits forests of much of the Caribbean lowlands and foothills, and scattered locations of the southern Pacific versant, from near sea level to ~1,200m. This relatively common species can be observed in the day, hopping among the leaf litter, or at night on low vegetation.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor obesus</SpeciesLatin>

<SpeciesEnglish>Obese Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor obesus is a medium-sized frog (~35– 62mm, ~1.4– 2.4in males; ~62– 86mm, ~2.4– 3.4in females). The skin is covered in low, rounded tubercles producing a rough texture. The eyes are large and have horizontal pupils and bronze, gray irises. Tympanic membranes are visible below supratympanic folds. The dorsal coloration is dark brown with scattered dark markings. The posterior thigh is dark with small yellow spots. The venter is granular with a yellow coloration, and the throat may be heavily pigmented. The digits have expanded terminal pads, and lateral fringes. The fingers lack webbing, but the toes have moderate to extensive webbing. A welldeveloped tarsal fold is also present. Males have a subgular vocal sac, and nuptial pads.</Description>

<SimilarSpecies>Craugastor obesus is most similar to C. rhyacobatrachus, but the latter has smaller terminal pads and less webbing. Other rugose, stream associated species include C. catalinae, C. ranoides and C. taurus. Craugastor catalinae has small toe discs, C. ranoides has less toe webbing and the tubercles of the dorsum are smaller, and C. taurus has a white venter and males lack nuptial pads.</SimilarSpecies>

<Calls>The advertisement call of Craugastor obesus is unknown.</Calls>

<RangeAndHabitat>Craugastor obesus is found in premontane forest of the eastern Talamancas at elevations of ~400 to 1,450m. This species is associated with steep gradient streams and is often found on rocks in the spray zone of cascades and waterfalls. Craugastor obesus has not been seen in Costa Rica since the 1980's and any encounters with this species should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor persimilis</SpeciesLatin>

<SpeciesEnglish>Similar Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor persimilis is a tiny to smallsized (~12– 22mm, ~0.5– 0.9in), but robust frog. The dorsal coloration is usually uniform, ranging from tannishorange to purplish gray. A fine light middorsal stripe is often present, and contrasting, irregular marking can sometimes be found on the flanks and dorsal surfaces of the body and limbs. There is a dark triangular seat patch surrounding and below the vent. On the side of the head there is relatively thick black supratympanic line. The dorsal skin is slightly granular, with some individuals having distinct rows of low tubercles. The eyes have a horizontal pupil, with a golden yellow to goldish-orange iris having a dark reticulation. The venter is light grayish-white and translucent. The hands and feet lack interdigital webbing and greatly expanded terminal discs on the digits; weakly expanded toe discs are spade shaped. The thenar tubercle is smaller than the palmar tubercle.</Description>

<SimilarSpecies>Craugastor persimilis could be confused with C. stejnegerianus, but they are not known to be sympatric, as C. stejnegerianus occurs on the Pacific slope. Craugastor bransfordii is similar in form and habit, but differs in having thenar and palmar tubercles of roughly the same size, and lacking the black seat patch.</SimilarSpecies>

<Calls>Males call at night from the tops of leaves on lowgrowing plants, and leaf litter. The advertisement call is a single, faint squeak repeated after a pause</Calls>

<RangeAndHabitat>Craugastor persimilis is endemic to Costa Rica, known to inhabit the lowlands and foothills of the central and southern Caribbean, from near sea level to ~1,200m. This relatively uncommon species is principally found in forests where they are often observed hopping among the leaf litter upon being disturbed, or occasionally on leaves of very low vegetation at night.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor phasma</SpeciesLatin>

<SpeciesEnglish>Ghost Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor phasma is a medium-sized frog (estimated size ~25– 30mm, ~1– 1.2in males; estimated ~35– 50mm, ~1.4– 2in females). The dorsal skin is smooth with a whitish gray ground color and a few small scattered dark spots. Tympanic membranes are small but visible below a supratympanic fold. The eyes are large and black in color. The venter is also whitish gray. The limbs are long and slender, and both the hands and feet lack webbing. The digits have expanded terminal pads, and those of fingers III and IV are largest.</Description>

<SimilarSpecies>With its gray/white color and black eyes, Craugastor phasma is not likely to be confused with any other anuran in Costa Rica.</SimilarSpecies>

<Calls>The advertisement call of Craugastor phasma is unknown.</Calls>

<RangeAndHabitat>Craugastor phasma is only known from the single (type) specimen collected from the lower montane rainforest of the Talamancas at an elevation of ~1,850m. The female frog was collected from banks of the Rio Coton at the beginning of the rainy season. No other individuals of this species have been found despite extensive search effort at the type locality. Any encounters with this species should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor podiciferus</SpeciesLatin>

<SpeciesEnglish>Piglet Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor podiciferus is a small to medium-sized frog (~20– 40 mm, ~0.8– 1.6 in). The skin is relatively smooth, often with paired dorsal folds and scattered, low tubercles. The

eyes are large, with horizontal pupils. Tympanic membranes are large, 1/2 to 3/4 the diameter of the eye on females and males respectively. The dorsal coloration is extremely variable, ranging from black to buff, but is usually brown or gray. A pale middorsal stripe may occur. A dark eye mask extends onto the body, bordered above by a fleshy fold. Dark spots or bars may occur on the lips and hind limbs. Ventral coloration of the head and body is pale, but the bottoms of the feet and tarsi are darker. Males have a small subgular vocal sac, but no nuptial pads. The fingers and toes are unwebbed and the ends of the digits lack greatly expanded pads. The tubercles on the digits, feet and hands are low and rounded; including the palmar tubercle that is larger than the thenar tubercle.</Description>

<SimilarSpecies>Craugastor podiciferus may be confused with other small Craugastor species including co-occurring C. underwoodi, or C. gollmeri. However, C. underwoodi is bumpier, has hand tubercles (palmar and thenar) of equal size and males have nuptial pads. Craugastor gollmeri has wider terminal pads on the digits, and is not as squat or robust.</SimilarSpecies>

<Calls>Males call at night from the leaf litter, producing a single “squeak”</Calls>

<RangeAndHabitat>This locally common species occurs in moist to wet primary forests of the Cordilleras ranging in elevation from ~1,100 to 2,650m. They are usually found in the day hopping through the leaf litter, or at night on the surface of leaf litter.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor polyptychus</SpeciesLatin>

<SpeciesEnglish>Many Folds Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor polyptychus is a small (~20– 30mm, ~0.8– 1.2in), but robust frog. The dorsal coloration is extremely variable among individuals, ranging from tan to dark brown, with a mixture of spots, bands, or irregular markings in assorted earthy tones. On the groin, thighs, and ventral surface of the lower leg, there is often a reddish-orange suffusion. The dorsal skin is granular, with some specimens also having numerous longitudinal fleshy ridges. The eyes have a horizontal pupil, with a gold to copper iris that often has dark spots or reticulation. The tympanic membrane is evident. The venter is light tan to gray with numerous lighter markings, especially on the throat. The hands and feet lack both expanded terminal discs and interdigital webbing. Males lack an enlarged nuptial pad at the base of finger I. The thenar and palmar tubercles are either nearly equal in size, or the palmar tubercle is slightly larger. The ventral surfaces of the hands and feet have numerous large projecting tubercles.</Description>

<SimilarSpecies>Craugastor polyptychus might be confused with C. bransfordii and C. underwoodi. Craugastor bransfordii males have an enlarged nuptial pad at the base of finger I (absent in C. polyptychus). Craugastor underwoodi differs in having rounded, less projecting tubercles on the ventral surfaces of the hands and feet.</SimilarSpecies>

<Calls>The advertisement call of Craugastor polyptychus consists of a quick chirp-like squeak.</Calls>

<RangeAndHabitat>Craugastor polyptychus is known to inhabit the Caribbean lowlands, from near sea level to ~100m. This common diurnal species can be found in a variety of habitats from old-growth forest to young secondary forest, and cacao plantations. Craugastor polyptychus is terrestrial, and is often seen hopping among the leaf litter on the forest floor.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor ranoides</SpeciesLatin>

<SpeciesEnglish>Ranid-like Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor ranoides is a medium-sized frog (~26– 45mm, ~1– 1.8in males; ~40– 74mm, ~1.6– 2.9in females). The dorsum has scattered tubercles giving a rough appearance. The tympanic membranes are visible below a supratympanic fold. Dorsal coloration is variable, usually a shade of brown or gray, with scattered dark blotches. The posterior thigh is dark with pale spots. The eyes have horizontal pupils and gold and brown irises. The venter is smooth and cream colored with more yellowish hues posteriorly and on the ventral surface of the thighs. The limbs are relatively short and stocky. The fingers lack webbing, but the toes have basal webbing. An inner tarsal fold is present. The digits have slightly expanded terminal pads, but males lack both nuptial pads and a vocal sac.</Description>

<SimilarSpecies>Craugastor ranoides may be confused with C. crassidigitus, C. fitzingeri, and C. fleischmanni. Craugastor crassidigitus has longer limbs, more toe webbing, and a solid brown posterior thigh. Craugastor fitzingeri differs in having wider terminal pads on the digits and a white mid-gular stripe. Craugastor fleischmanni has smaller terminal pads on the digits, and lacks the dark posterior thigh marked with pale spots. </SimilarSpecies>

<Calls>The advertisement call of Craugastor ranoides is unknown.</Calls>

<RangeAndHabitat>Craugastor ranoides was formerly a very common nocturnal frog found at elevations from near sea level to ~1,300m on both the Pacific and Atlantic slopes. They are usually found in or near streams and can be found sitting on rocks or foraging in streamside habitats. Craugastor ranoides has disappeared from most of its former range, but small populations still occur in the Guanacaste region. Encounters with this species in other portions of their range should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor rayo</SpeciesLatin>

<SpeciesEnglish>Lightning Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor rayo is a medium-sized frog (~37– 45mm, ~1.5– 1.8in males; ~38– 71mm, ~1.5– 2.8in females). The dorsum is smooth and dark brown with a bluish purple tint in males and more brown to tan in females. The tympanic membranes are obscure below a darkly pigmented supratympanic fold. A pale vertebral stripe may occur, and the posterior thigh is dark purple with small, pale dots. The venter is smooth and pale, colored with dark mottling. The throat has a mid-gular light stripe. The digits have expanded terminal pads and lateral fringes. The fingers lack webbing, and the toes have very limited (basal) webbing. There is a tarsal fold and a tubercle on the heel. Males have a subgular vocal sac and pale nuptial pads.</Description>

<SimilarSpecies>Craugastor rayo is similar overall to C. andi and C. talamancae, but both of these latter species lack the evident heel tubercle. Furthermore, C. andi has a more vividly marked posterior thigh, and C. talamancae has a dark eye mask and white lip stripe.</SimilarSpecies>

<Calls>The male holotype of Craugastor rayo was found calling from a bromeliad during a heavy daytime rain. But, the advertisement call for this species is unknown.</Calls>

<RangeAndHabitat>Craugastor rayo is a rare frog found on the Pacific versant in the premontane and lower montane forests of the Talamancas at elevations of ~1,500 to 1,800m. Individuals have been found in or near streams. This species has not been reported since the 1980s, and any encounters should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor rhyacobatrachus</SpeciesLatin>

<SpeciesEnglish>Torrent Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor rhyacobatrachus is a medium to large-sized frog (~40– 50mm, ~1.6– 2in males; ~50– 80mm, ~2– 3.2in females). The skin has a rough or bumpy appearance due to the numerous tubercles of various sizes. The eyes have horizontal pupils and a dark/black iris. Tympanic membranes are visible under supratympanic folds. The dorsal coloration is dark brown with dark markings and the posterior thigh is brown with pale yellow spots. The venter is pale yellow with dark markings. The digits have expanded terminal discs. The fingers lack webbing, but the toes have extensive webbing and lateral fringes. There is also a tarsal fold present. Males have nuptial pads and a vocal sac.</Description>

<SimilarSpecies>Craugastor rhyacobatrachus may be confused with closely related C. catalinae, C. fleischmanni, C. obesus, or C. taurus. The terminal pads on the digits of Craugastor catalinae, C. fleischmanni, and C. taurus are smaller than those of C. rhyacobatrachus, and C. catalinae also has less toe webbing. The toes of C. obesus are slightly more webbed and have larger terminal discs than C. rhyacobatrachus.</SimilarSpecies>

<Calls>The advertisement call of Craugastor rhyacobatrachus is not known.</Calls>

<RangeAndHabitat>Craugastor rhyacobatrachus occurs in premontane and lower montane forests on the Pacific slope of the Talamancas at elevations ranging from ~950 to 1,800m. They are nocturnal and may be found on rocks in high gradient streams. Although C. rhyacobatrachus has a limited range, it was locally abundant. However, it has declined across its range, and may be extirpated from Costa Rica. Any encounters with the species should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor rugosus</SpeciesLatin>

<SpeciesEnglish>Wrinkled Flesh-bellied Frog</SpeciesEnglish>

<Description>Craugastor rugosus is a medium-sized frog (estimated ~30– 44mm, ~1.2– 1.7in males; ~35– 69mm, ~1.4– 2.7in females) with a large head. The dorsum has numerous tubercles giving a bumpy appearance. A pair of arcing folds extend from the eye posteriorly, and another pair of folds occurs above the pelvis. The dorsal coloration is variable, usually brown or gray, occasionally black, with scattered dark markings. The posterior thigh is red with dark vertical bars (white and black in juveniles). The tympanic membrane is easily visible below a dark supratympanic fold that curves down to the shoulder. The eyes are large, and have horizontal pupils and gold/ brass irises with dark reticulations. The venter is granular and cream colored. The limbs are short and stout. The fingers and toes lack webbing, and the digits have slightly expanded terminal pads. Males lack both nuptial pads and a vocal sac.</Description>

<SimilarSpecies>Craugastor rugosus may be confused with the other large-headed Craugastor species, C. gulosus and C. megacephalus. Nonetheless, Craugastor gulosus differs in being larger and having a smooth dorsum. Craugastor megacephalus is most similar in morphology, but lacks the red posterior thigh with black bars (white and black in juvenile C. rugosus) and occurs on the Atlantic versant.</SimilarSpecies>

<Calls>The advertisement call of Craugastor rugosus is not known.</Calls>

<RangeAndHabitat>Craugastor rugosus is a nocturnal species occurring in lowland and premontane forests of the southeastern Pacific versant. The elevational range for Craugastor rugosus is from near sea level to ~1,200m. These frogs are terrestrial and are often encountered on the forest floor. They are presumed sit and wait predators, similar to C. megacephalus.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Craugastor rugosus</SpeciesLatin>

<SpeciesEnglish>Wrinkled Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor rugosus is a medium-sized frog (estimated ~30– 44mm, ~1.2– 1.7in males; ~35– 69mm, ~1.4– 2.7in females) with a large head. The dorsum has numerous tubercles giving a bumpy appearance. A pair of arcing folds extend from the eye posteriorly, and another pair of folds occurs above the pelvis. The dorsal coloration is variable, usually brown or gray, occasionally black, with scattered dark markings. The posterior thigh is red with dark vertical bars (white and black in juveniles). The tympanic membrane is easily visible below a dark supratympanic fold that curves down to the shoulder. The eyes are large, and have horizontal pupils and gold/ brass irises with dark reticulations. The venter is granular and cream colored. The limbs are short and stout. The fingers and toes lack webbing, and the digits have slightly expanded terminal pads. Males lack both nuptial pads and a vocal sac.</Description>
<SimilarSpecies>Craugastor rugosus may be confused with the other large-headed Craugastor species, C. gulosus and C. megacephalus. Nonetheless, Craugastor gulosus differs in being larger and having a smooth dorsum. Craugastor megacephalus is most similar in morphology, but lacks the red posterior thigh with black bars (white and black in juvenile C. rugosus) and occurs on the Atlantic versant.</SimilarSpecies>
<Calls>The advertisement call of Craugastor rugosus is not known.</Calls>
<RangeAndHabitat>Craugastor rugosus is a nocturnal species occurring in lowland and premontane forests of the southeastern Pacific versant. The elevational range for Craugastor rugosus is from near sea level to ~1,200m. These frogs are terrestrial and are often encountered on the forest floor. They are presumed sit and wait predators, similar to C. megacephalus.</RangeAndHabitat>
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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor stejnegerianus</SpeciesLatin>
<SpeciesEnglish>Stejneger’s Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor stejnegerianus is a small-sized frog (~12– 22mm, ~0.5– 0.8in). The skin is relatively granular with dorsal folds and scattered tubercles dorsally and ventrally. The head is smooth and the snout is short. The eyes are large, with horizontal pupils and copper or brass colored irises. There are small tubercles above the eyes. Tympanic membranes are large (1 to 2/3 diameter of the eye, male and female respectively). A darkly pigmented supratympanic ridge extends down to the shoulder. The dorsal coloration is variable, but is usually brown or gray. Darker blotches are often present, which may include bars extending from the snout to the shoulder, and/or a seat patch. The limbs may be marked with dark bars, and a light colored middorsal stripe may occur. Males lack both vocal sacs and nuptial pads. The fingers and toes are unwebbed with noticeable tubercles on digits, feet and hands; including a palmar tubercle that is larger than the thenar tubercle.</Description>
<SimilarSpecies>Craugastor stejnegerianus appears very similar to other small Craugastor species and is most easily identified by its distribution, as the other species are found at higher elevations (C. gabbi, C. podiciferus and C. underwoodi), or on the Atlantic slope (C. bransfordii, C. persimilis, and C. polyptychus). The rarely co-occurring C. underwoodi differs in having the thenar tubercle roughly the same size as the palmar tubercle, and males have nuptial pads.</SimilarSpecies>
<Calls>Males call at night from the surface of low vegetation, producing a single “squeak” repeated after a pause</Calls>
<RangeAndHabitat>This very common species occurs in nearly all moist to wet locales (forests to disturbed areas), from near sea level to ~1,350m. They are usually found in the in the day hopping in the leaf litter, or active at night.</RangeAndHabitat>
<PageNumber>105</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor talamancae</SpeciesLatin>
<SpeciesEnglish>Talamancan Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor talamancae is a small to mediumsized frog (~20– 50mm; ~0.8–2in). The skin is slightly granular dorsally, and smooth ventrally. The eyes are large, with horizontal pupils, and pale gold irises. Tympanic membranes are large (~2/3 to 1/2 the size of the eye in males and females respectively) and readily visible below supratympanic folds that curve down towards the shoulder. Dorsal coloration is brown, with a dark eye mask and a contrasting light lip stripe that may extend onto the body. Additional light stripes may extend obliquely near the groin. Dark bars alternate with lighter colors on the limbs dorsally. The posterior thigh and groin has a reddish tint. The venter is white, but may have scattered dark spots. Males have pale nuptial pads and a small, internal vocal sac. Fingers and toes have expanded terminal pads. Fingers lack webbing, but the toes have limited webbing.</Description>
<SimilarSpecies>Craugastor talamancae may be confused with C. gollmeri, C. mimus, and C. noblei. However, these all lack the light lip stripe and have the dark mask clearly extending onto the body. Craugastor gollmeri differs further in having the upper half of the iris red. Craugastor crassidigitus and C. fitzingeri generally lack the dark eye mask and light lip stripe, and differ further with C. crassidigitus having more extensive toe webbing, and C. fitzingeri having a white gular stripe.</SimilarSpecies>
<Calls>Males call at night from low vegetation, producing a “mew” or “squeak” note repeated after long pauses</Calls>
<RangeAndHabitat>Craugastor talamancae is a common species occurring in lowland moist and wet forests on the Atlantic slope, ranging from near sea level to ~650m. They are usually found while active (night) on low vegetation, but may also be encountered during the daytime in leaf litter.</RangeAndHabitat>
<PageNumber>106</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor taurus</SpeciesLatin>
<SpeciesEnglish>Bull Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor taurus is a medium to largesized frog (~24– 44mm, ~0.9– 1.7in males; ~40– 80mm, ~1.6– 3.2in females). The dorsum has scattered tubercles giving a bumpy appearance. The dorsum is tan or gray with dark markings. Pale spots or bars occur on the lip. The posterior thigh is dark with pale markings. Tympanic membranes are easily visible, they are large and round in males, and smaller and oval in females. The eyes have a horizontal pupil and a gold iris. The venter is granular, and white to cream colored with dark markings on the throat. The digits have slightly expanded terminal pads. Webbing is absent on the hands, but the toes are moderately webbed and have lateral fringes. A tarsal fold is also present. Males have a subgular vocal sac, but lack nuptial pads.</Description>
<SimilarSpecies>Craugastor taurus, is most likely to be confused with other stream-associated Craugastor species. Craugastor fleischmanni has smoother skin, less toe webbing and occurs at higher elevations. The terminal pads of the digits are larger on C. catalinae, C. obesus and C. rhyacobatrachus.</SimilarSpecies>
<Calls>The advertisement call of Craugastor taurus is not known.</Calls>
<RangeAndHabitat>Craugastor taurus is a formerly common nocturnal frog found in lowland forests of the southeastern Pacific versant. Historically they ranged in elevation from near sea level to ~550m. They are usually encountered in or near streams where they forage. Craugastor taurus is yet another species that has experienced severe declines across most of its range. Encounters with this species should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Craugastor underwoodi</SpeciesLatin>
<SpeciesEnglish>Underwood's Flesh-bellied Frog</SpeciesEnglish>
<Description>Craugastor underwoodi is a small (~20– 30mm, ~0.8– 1.2in), but robust frog. The dorsal coloration is extremely variable, ranging from tan to dark brown, with a mixture of spots, bands, or irregular markings in assorted earthy tones. The groin, thighs, and ventral surface of the lower leg, often have a reddishorange suffusion. The dorsal skin is granular, with some specimens also having numerous longitudinal fleshy ridges. The eyes have a horizontal pupil and a gold to copper iris with dark spots or reticulation. The tympanic membrane is evident, and slightly larger on males. The venter is light tan to gray with numerous lighter markings, especially on the throat. The hands and feet lack both expanded terminal discs and interdigital webbing. Males have an enlarged nuptial pad, but lack a vocal sac. The thenar and palmar tubercles are either nearly equal in size, or the palmar tubercle is slightly larger. The ventral surfaces of the hands and feet have numerous large, but smooth tubercles.</Description>
<SimilarSpecies>Craugastor underwoodi might be confused with C. bransfordii and C. polyptychus. Craugastor underwoodi is slightly larger and typically has smoother, less projecting tubercles on the ventral surfaces of the hands and feet than C. bransfordii. Craugastor polyptychus males lack nuptial pads, and occur at much lower elevations.</SimilarSpecies>
<Calls>Males call from the leaf litter or low-growing plants. The advertisement call consists of a quick, chirp-like squeak sometimes in two rapid notes</Calls>
<RangeAndHabitat>Craugastor underwoodi occurs throughout much of the Caribbean versant and at scattered sites on the Pacific versant as well, from ~900 to 1,600m. This common diurnal species can be found in a variety of habitats from old-growth forest to young secondary forest. Craugastor underwoodi is principally terrestrial, and is often seen hopping among the leaf litter on the forest floor.</RangeAndHabitat>
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</FrogSpecies>
<!--Craugastoridae (Craugastor) End-->

<!--Craugastoridae (Pristimantis)-->
<FrogSpecies>
<SpeciesLatin>Pristimantis altae</SpeciesLatin>
<SpeciesEnglish>Coral-spotted Robber Frog</SpeciesEnglish>
<Description>Pristimantis altae is a tiny to small-sized frog (~18– 27mm, ~0.7–1.1in). The dorsal coloration typically ranges from a uniform light tannish gray to dark reddish-brown or dark brownish-gray. Often there is some white pigmentation where the arms meet the body. On the groin and anterior thighs there are bright markings that range in color from yellowish-orange to reddishorange. The dorsal skin is smooth to weakly granular. The eyes have a horizontal pupil, with a gray, yellowish-gold, or grayish-copper iris. The ventral surface of the body and limbs is typically gray to dark brownish-gray. The hands and feet lack interdigital webbing, but have expanded discs on the tips of the digits. Males lack nuptial pads and but have a large subgular vocal sac.</Description>
<SimilarSpecies>Pristimantis altae, with its uniform dorsum and brightly salmon-colored groin and anterior thighs is not likely to be confused with any other frog from Costa Rica.</SimilarSpecies>
<Calls>Males call at night from the surface of leaves on low-growing vegetation. The advertisement call consists of series of two to four quick "tik" like notes, similar to the sound made when hitting two small stones together</Calls>

<RangeAndHabitat>Pristimantis altae has been found at scattered sites throughout much of the Caribbean versant. This species is found in premontane forests, but has also been recorded in some lowland sites as well. The known elevational range is from ~50 to 1,500m, but this species is most frequently encountered between 500 to 1,500m. This relatively uncommon nocturnal species is typically found in old-growth and secondary forests, but can be observed in disturbed open areas as well. Pristimantis altae is normally observed on the vegetation in the forest understory.</RangeAndHabitat>
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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Pristimantis caryophyllaceus</SpeciesLatin>
<SpeciesEnglish>Sharp-snouted Robber Frog</SpeciesEnglish>
<Description>Pristimantis caryophyllaceus is a finely structured small frog (~20– 30 mm, 0.8– 1.2in). The dorsal coloration ranges from a light yellowish-tan to brown, or brownish-gray. Normally there are darker bands on the dorsal surfaces of the limbs and body; often these dark bands form a chevron pattern on the back. Occasionally white or black spots occur on the dorsal surfaces, where they may form part of the chevron shaped bands. The dorsal skin is smooth to very weakly granular. The eyes have a horizontal pupil, with a silvery-gray, yellowish-gold, orange, or red iris. On the upper eyelid there is a weak to evident supraocular tubercle. The snout is elongate and finely structured, coming to a bluntly pointed tip. The ventral surfaces of the body and limbs are translucent, with a white peritoneum visible through the skin. The hands and feet lack interdigital webbing, but have rounded terminal discs on the digits. There is a large pointed tubercle projecting from the heel.</Description>
<SimilarSpecies>Pristimantis caryophyllaceus, with its large heel tubercle, fine pointed snout, and lack of contrasting colors in the groin or on the anterior dorsal thigh, is not likely to be confused with other frogs in Costa Rica.</SimilarSpecies>
<Calls>The advertisement call of Pristimantis caryophyllaceus has not been formerly described, but consists of several sharp “tik” notes.</Calls>
<RangeAndHabitat>Pristimantis caryophyllaceus has been found at scattered sites throughout much of the Caribbean versant. This species is principally found in premontane forests, but has also occurs in some lowland sites as well. The elevational range is from near sea level to ~1,900m. This relatively uncommon nocturnal species is typically found in old-growth and secondary forests, where it can be observed on the understory vegetation.</RangeAndHabitat>
<PageNumber>110</PageNumber>
</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Pristimantis cerasinus</SpeciesLatin>
<SpeciesEnglish>Cherry-thighed Robber Frog</SpeciesEnglish>
<Description>Pristimantis cerasinus is a small to moderatesized frog (~20– 40mm, ~0.8– 1.6in). The dorsal coloration ranges from a light tannishorange to reddish-brown, often with additional irregular markings in a mixture of contrasting earthy tones. Normally there are red to purplish-red markings on the groin and anterior surface of the thigh, but these are subject to metachrosis, and may be lacking when observed in the field. The dorsal skin is smooth to weakly granular, with numerous small tubercles often scattered throughout, especially on the legs and forearms. There is a fleshy ridge between the eyes and the suprascapular region that forms a “W” shape. The eyes have a horizontal pupil, with a silvery-gray, orange, or yellow iris. A weak supraocular tubercle may be present. The snout is elongate and bluntly pointed. The ventral surface of the body is pale, and weakly translucent in some individuals; often with a contrasting gray reticulation or spotting. A large pointed tubercle is present on the heel. The hands and feet lack webbing, but have expanded terminal discs.</Description>

<SimilarSpecies>Pristimantis cerasinus may be confused with P. cruentus, but the latter species lacks red to purplish-red markings on the groin and thigh.</SimilarSpecies>

<Calls>The advertisement call of Pristimantis cerasinus is a single quick, high-pitched squeak-like note</Calls>

<RangeAndHabitat>Pristimantis cerasinus occurs throughout much of the lowlands and foothills along the Caribbean versant at elevations ranging from near sea level to ~1,400m. This relatively common nocturnal species is usually found in old-growth and secondary forests, but can additionally be observed in more disturbed habitats. They are normally found at night on the vegetation in the forest understory, but can at times be observed hoping among the leaf litter during the day.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Pristimantis cruentus</SpeciesLatin>

<SpeciesEnglish>Bloody Robber Frog</SpeciesEnglish>

<Description>Pristimantis cruentus is a small to moderatesized frog (~15– 40mm, ~0.6–1.6in). The dorsal coloration is highly variable, ranging from a light tan, light brown, dark brown, greenish-brown, green, to gray. The dorsal surfaces often have additional irregular markings, spots, or bands in a mixture of contrasting earthy tones. Normally there are bright yellow to red markings on the groin and anterior and posterior surface of the thigh. The dorsal skin is granular to heavily tuberculate, with a fleshy ridge between the eyes and the suprascapular region that forms a “W” shape. The eyes have a horizontal pupil, with an iris varying in color from light yellow to bright red, often with a dark reticulation. The ventral surface of the body is pale and often has contrasting dark reticulation or spotting. An evident and large pointed tubercle is present on the heel and above the eye. The hands and feet lack interdigital webbing, and have expanded terminal discs on the digits that are truncate to rounded.</Description>

<SimilarSpecies>Pristimantis cruentus is most likely to be confused with Pristimantis cerasinus or Craugastor melanostictus. Pristimantis cerasinus differs in having red to purplish-red markings on the groin and thigh. Craugastor melanostictus differs in having toe III longer than toe V.</SimilarSpecies>

<Calls>Males call at night from low vegetation, usually producing a single, faint buzz-like or quack-like note</Calls>

<RangeAndHabitat>Pristimantis cruentus occurs on both the Caribbean versant, and the central and southern Pacific versant at elevations ranging from near sea level to ~1,800m, but this species is most commonly observed within the premontane and marginally into the lower montane zonations. This relatively common nocturnal species is most often found on understory vegetation in old-growth and secondary forests, but can additionally be observed in more disturbed habitats.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Pristimantis gaigei</SpeciesLatin>

<SpeciesEnglish>Gaige’s Robber Frog</SpeciesEnglish>

<Description>Pristimantis gaigei is a small to moderatesized frog (~25–45mm, ~1–1.8in). The dorsal coloration, which can closely resemble that of Phyllobates vittatus or P. lugubris, is dark brown to black with a pair of light dorsolateral stripes which can be bright orange to brownish yellow. The legs and arms are often mottled with a mixture of turquoise to gray and dark brown to black. The dorsal skin is smooth to weakly granular. The venter is usually gray and may be marked with pale blotches (silver, blue or bluegreen); some individuals have a brown venter. The eyes have a horizontal pupil, with a gold to copper iris that often has a concentration of dark spots or reticulation. The tympanic membrane is readily

visible (larger in males). The hands and feet lack interdigital webbing, and have slightly expanded terminal discs. Males lack both nuptial pads and a vocal sac.</Description>

<SimilarSpecies>Pristimantis gaigei is most likely to be confused with Phyllobates vittatus and P. lugubris. Pristimantis gaigei can be distinguished from the two Phyllobates species due to the coloration of the iris, being light gold to copper in P. gaigei, yet dark brown in the two Phyllobates species.</SimilarSpecies>

<Calls>The advertisement call of Pristimantis gaigei is unknown.</Calls>

<RangeAndHabitat>Within Costa Rica Pristimantis gaigei is only known to inhabit a small area of the Caribbean lowlands in the extreme eastern corner of Costa Rica, from near sea level to ~200m. This relatively rare nocturnal species is typically found in old-growth and secondary forests, and is principally terrestrial.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Pristimantis moro</SpeciesLatin>

<SpeciesEnglish>Mohr's Robber Frog</SpeciesEnglish>

<Description>Pristimantis moro is a tiny to small-sized frog (~17– 25 mm, ~0.7– 1in). The dorsal coloration is known to range from bright green to reddish-orange. The dorsal skin is smooth to weakly granular, lacking distinct tubercles on the upper eyelid and on the heel. The eyes have a horizontal pupil, with an iris that can range from silvery-gold to reddish-orange. A small tympanic membrane is visible. The ventral surface of the body is pale with translucent skin. The hands and feet lack interdigital webbing, and have expanded, rounded discs on the tips of most of the digits. Males have a small subgular vocal sac, but lack nuptial pads.</Description>

<SimilarSpecies>Pristimantis moro might be mistaken for other small Pristimantis species such as P. caryophyllaceus, P. cruentus or P. ridens. However, these differ in having supraocular and heel tubercles. Isthmohyla zeteki is superficially similar in appearance to brown morphs of P. moro, and occurs in the same microhabitats, but differs in having a dark "mustache", more forward-facing eyes, and interdigital webbing (although limited).</SimilarSpecies>

<Calls>The advertisement call of Pristimantis moro is unknown.</Calls>

<RangeAndHabitat>Pristimantis moro has been documented to inhabit the premontane forests of Caribbean slopes of the Central Volcanic Range at elevations ranging from ~900m to 1,250m, but it is very likely that this species has a continuous distribution down along the Caribbean premontane forest of the Talamancan mountains. This rare and enigmatic nocturnal species is known to inhabit oldgrowth and secondary forest, being found within bromeliads and on the vegetation of the forest's understory.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Pristimantis pardalis</SpeciesLatin>

<SpeciesEnglish>Leopard Robber Frog</SpeciesEnglish>

<Description>Pristimantis pardalis is a small-sized frog (~16– 19mm, ~0.6– 0.8in males; ~25– 29mm, ~1– 1.1in females). The dorsum may be smooth to somewhat granular, with scattered low tubercles. The dorsal coloration is a dark gray or brown. White spots and markings occur on the groin and both the anterior and posterior thigh. The tympanic membranes are small and indistinct. Pristimantis pardalis has large eyes with horizontal pupils and copper irises with dark reticulations. The venter is gray with abundant pale specks. The limbs are long and slender. The hands and feet lack webbing but the digits

have large, rounded terminal pads. Males do not have nuptial pads, but have a subgular vocal sac.</Description>

<SimilarSpecies>Pristimantis pardalis is similar morphologically to closely related Pristimantis altae. However, coral or orangish pink spots on the groin and anterior thigh as opposed to white (P. pardalis) distinguishes P. altae</SimilarSpecies>

<Calls>Males call at night from understory vegetation or the lower reaches of trees. The advertisement call of Pristimantis pardalis is very similar to that of P. altae, consisting of a small group of "tik" like notes, sounding similar to sharply knocking two small stones together</Calls>

<RangeAndHabitat>Pristimantis pardalis is an uncommon nocturnal species usually encountered on low vegetation in primary premontane forests of both Atlantic and Pacific slopes of the eastern Talamancas. They occur at elevations ranging from ~350 to 1,450m.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Pristimantis ridens</SpeciesLatin>

<SpeciesEnglish>Pygmy Robber Frog</SpeciesEnglish>

<Description>Pristimantis ridens is a tiny to small-sized frog (~16– 25mm, ~0.6– 1in). The dorsal coloration ranges from light yellowish-tan, beige, to reddishbrown. A dark supratympanic line is usually present, as are grayish diagonal bands on the flanks and dorsal surfaces of the legs. A dark interorbital band contrasted anteriorly by a pale color usually occurs. Occasionally a fine light middorsal stripe may be present. On the groin and parts of the legs, there is often a reddish-orange to pink coloration. The dorsum can range from being nearly smooth to weakly tuberculate. The eyes have a horizontal pupil, with an iris that is typically silvery-gray to golden-orange. Most individuals have a small, but well-defined and pointed supraocular tubercle. The venter is light grayishwhite and translucent. The heel has a small weak tubercle. The hands and feet lack interdigital webbing, but have expanded terminal discs on the digits that are rounded.</Description>

<SimilarSpecies>Pristimantis ridens may be confused with P. caryophyllaceus and P. moro. Nonetheless, P. caryophyllaceus differs in having a longer, more angular snout and much larger heel tubercles. Pristimantis moro differs by lacking supraocular and heel tubercles, and lack of reddish-orange to pink coloration on the groin and legs.</SimilarSpecies>

<Calls>Males call at night from low vegetation. The advertisement call of Pristimantis ridens is a low trill-like series of notes, reminiscent of a soft rapid giggle</Calls>

<RangeAndHabitat>Pristimantis ridens occurs throughout much of Costa Rica, with the exception of dry Guanacaste regions, from near sea level to ~1,600m. This common nocturnal species can be found in wide variety of habitat types, from old-growth and secondary forests to open disturbed habitats such as gardens. They are often found at night sitting on low vegetation.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Pristimantis taeniatus</SpeciesLatin>

<SpeciesEnglish>Striped Robber Frog</SpeciesEnglish>

<Description>Pristimantis taeniatus is a tiny to smallsized frog (~15– 32mm, ~0.6– 1.3in males). The dorsum is smooth and colored in various shades of brown with a variety of markings or patterns occurring. The most common form lacks stripes dorsally and has a dark-colored "W" shape at the back of the head and dark bars on the legs. Some individuals have various forms of pale and/or dark longitudinal stripes. The eyes have a horizontal pupil and a gold iris. Small supraocular tubercles occur. Tympanic membranes are small but visible below supratympanic folds that are darkly colored. The venter

is slightly granular and cream colored with numerous brown flecks. The hands and feet lack interdigital webbing, but digits have expanded terminal pads and lateral fringes. Males have nuptial pads and a subgular vocal sac.</Description>

<SimilarSpecies>Pristimantis taeniatus is similar to other small Pristimantis species. Nonetheless, these differ as follows P. caryophyllaceus and P. ridens both have heel tubercles, P. moro lacks the supraocular tubercle, and all these species lack lateral fringes on the digits. Small Craugastor species with similar dark supratympanic folds (ex. C. stejnegerianus) all lack the enlarged terminal disks on the digits.</SimilarSpecies>

<Calls>Males call at night from low-growing vegetation, producing a short, single note.</Calls>

<RangeAndHabitat>Pristimantis taeniatus is a rarely encountered species that occurs in premontane forests on the Pacific versant in the eastern Talamancas. It is known from elevations of ~1,000 to 1,150m.</RangeAndHabitat>

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</FrogSpecies>

<!--Craugastoridae (Pristimantis) End-->

<!--Craugastoridae (Strabomantis)-->

<FrogSpecies>

<SpeciesLatin>Strabomantis bufoniformis</SpeciesLatin>

<SpeciesEnglish>Toad-like Robber Frog</SpeciesEnglish>

<Description>Strabomantis bufoniformis is a medium to large-sized frog (~50– 95mm, ~2– 3.8in) that resembles a toad in its robust body and short, stocky limbs. The skin is covered in whitetipped tubercles giving a very bumpy appearance. The dorsal coloration is various shades of brown with dark blotches, and dark bars may occur on the hind limbs. Contrasting dark and pale spots may occur on the lip. The head is wide and the snout is short. The eyes are large, with horizontal/round pupils and a dark horizontal, hourglass-shaped bar through the iris. Tympanic membranes are present, but indistinct. The ventral color is light (white to yellow) with dark spots. Males have a single, small vocal sac, but lack nuptial pads. The fingers lack webbing and expanded pads. The toes have limited webbing with slightly expanded terminal pads.</Description>

<SimilarSpecies>Strabomantis bufoniformis appears similar to broad-headed Craugastor species including C. gulosus, C. megacephalus, and C. rugosus. However, these all lack the toe webbing present in S. bufoniformis.</SimilarSpecies>

<Calls>Males produce a weak call consisting of series of short “chuck” or bark-like calls with several seconds between each call.</Calls>

<RangeAndHabitat>Strabomantis bufoniformis is rare in Costa Rica, and has not been seen since the 1980s. They occur in, or near streams in lowland primary rainforests from near sea level to ~50m. Any encounters with this species should be carefully documented.</RangeAndHabitat>

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</FrogSpecies>

<!--Craugastoridae (Strabomantis) End-->

<!--Dendrobatidae (Dendrobates)-->

<FrogSpecies>

<SpeciesLatin>Dendrobates auratus</SpeciesLatin>

<SpeciesEnglish>Green and Black Poison Frog</SpeciesEnglish>

<Description>Dendrobates auratus is a moderate-sized (~30– 40 mm, ~1.2– 1.6in), and robust frog. This species has smooth skin, that can range in color from bluish-green, green, to yellow green with dark brown to black bands, stripes, and spots. There is a marked difference in the overall coloration

between populations of D. auratus from the Caribbean and Pacific versants, with those on the Caribbean typically having more prominent bluish-green to green light areas, and narrower dark markings. The populations on the Pacific versant normally have more dominant dark markings with sparse yellowish-green light areas. The eyes are large with horizontal pupils and very dark irises. The fingers and toes lack interdigital webbing. Males have a subgular vocal sac, but lack nuptial pads as they do not grasp females in amplexus.</Description>

<SimilarSpecies>Dendrobates auratus is not likely to be confused with any other anuran species in Costa Rica.</SimilarSpecies>

<Calls>Males call sporadically during the day from hidden locations among understory vegetation producing a long, low frequency buzz, typically lasting 2 to 5 seconds</Calls>

<RangeAndHabitat>Dendrobates auratus is found on both the Caribbean and Pacific versants, inhabiting much of the lowlands and foothills on the Caribbean versant, with the exception of the northwestern corner. On the Pacific versant, they occur within the lowland and humid forest of the central and southern Pacific, roughly from the Río Tarcoles region southward. The elevational range is from near sea level to ~800m. This diurnal species can be common in a wide variety of habitats, ranging from primary forest to young secondary growth and gardens.</RangeAndHabitat>

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</FrogSpecies>

<!--Dendrobatidae (Dendrobates) End-->

<!--Dendrobatidae (Oophaga)-->

<FrogSpecies>

<SpeciesLatin>Oophaga granulifera</SpeciesLatin>

<SpeciesEnglish>Granular Poison Frog</SpeciesEnglish>

<Description>Oophaga granulifera is a small-sized frog (~18– 25mm, ~0.7– 1in). This species has granular dorsal skin that can be orange, red, yellow, or green; with secondary colors on the dorsum and limbs that range from light gray to turquoise-blue. Oophaga granulifera can be variable in color and pattern throughout its range in Costa Rica. The fingers and toes lack interdigital webbing.</Description>

<SimilarSpecies>Oophaga granulifera is most likely to be confused with its close relative O. pumilio. However, O. granulifera has a granular texture of the dorsum, whereas the dorsum of O. pumilio is smooth. Further, these two species are allopatric, with O. granulifera found on the Pacific versant, and O. pumilio found on the Caribbean versant in Costa Rica.</SimilarSpecies>

<Calls>Males call from understory perch sites within their territories throughout the day, but most frequently in the mornings and afternoons. The call is a long series (often lasting 30 seconds or more) of slowly repeated raspy notes, similar to O. pumilio, but much slower</Calls>

<RangeAndHabitat>Oophaga granulifera is principally found along the foothills of the central and southern Pacific region. The elevational range for O. granulifera is from near sea level to ~600m. This diurnal species is typically not found as commonly as its Caribbean versant sister species, O. pumilio, but at some sites O. granulifera can be found in decent densities, especially within the humid leaf litter bordering streams during the dry season. Oophaga granulifera can be found in a variety of habitat types, but most commonly it inhabits mature forest. They often tend to prefer forest growing along the riparian slopes of streams and rivers.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>

<SpeciesLatin>Oophaga pumilio</SpeciesLatin>

<SpeciesEnglish>Blue-jeans, Strawberry, or Red Poison Frog</SpeciesEnglish>

<Description>Oophaga pumilio is a small-sized (~18– 25mm, ~0.7– 1in), but robust frog. This species has smooth skin that typically ranges in color from bright orange to blood red, and often having secondary colors on the dorsum and limbs that range from black to bright blue. Oophaga pumilio is highly variable in color and pattern throughout its range in Costa Rica. The eyes are large, and have a horizontal pupil and dark iris. The fingers and toes lack interdigital webbing. Males have a dark, subgular vocal sac, but lack nuptial pads.</Description>

<SimilarSpecies>Oophaga pumilio is most likely to be confused with its close relative O. granulifera, but these two species are allopatric, with O. pumilio known from the Caribbean versant of Costa Rica, whereas O. granulifera is known from the Pacific versant. In addition to the geographic separation, O. granulifera has a granular texture of the dorsum that is unknown in Costa Rican populations of O. pumilio.</SimilarSpecies>

<Calls>Males call throughout the day, but especially in the mornings and afternoons, from understory perches within their territories. The call of Oophaga pumilio is a long series of loud rapidly repeated short raspy notes, than often lasts 30 seconds or more</Calls>

<RangeAndHabitat>Oophaga pumilio is found throughout much of lowlands and foothills of the Caribbean versant. The known elevational range for O. pumilio is from near sea level to ~800m. This diurnal species can be common in a wide variety of habitats, ranging from primary forest to young secondary growth and gardens. Oophaga pumilio often tends to prefer edge habitats such as forest margins, or the vegetation along roadsides.</RangeAndHabitat>

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</FrogSpecies>

<!--Dendrobatidae (Oophaga) End-->

<!--Dendrobatidae (Phyllobates)-->

<FrogSpecies>

<SpeciesLatin>Phyllobates lugubris</SpeciesLatin>

<SpeciesEnglish>Lovely or Yellow-striped Poison Frog</SpeciesEnglish>

<Description>Phyllobates lugubris is a small (~18– 25mm, ~0.7– 1in), but robust frog. This species has smooth dark brown to black dorsal skin with a pair of light dorsolateral stripes that range from dark yellow to yellowish white, and extend from the tip of the snout to the sacrum. Some individuals may have smaller spots similarly colored in the center of the dorsum. The ventral surface of the body is dark brown to black with lighter white to greenish-blue spots scattered throughout. The upper surfaces of the limbs are heavily pigmented by lighter copper to brown spots. The eyes are large with horizontal pupils and dark irises. The fingers and toes lack interdigital webbing. Males have a subgular vocal sac, but lack nuptial pads.</Description>

<SimilarSpecies>Phyllobates lugubris is similar in general appearance to Allobates talamancae, P. vittatus, and Pacific versant Silverstoneia flotator. Allobates talamancae differs from P. lugubris in having cream to light brown dorsolateral stripes, and a solid white venter. Phyllobates vittatus is most similar, but has thicker, light orange to reddish orange dorsolateral stripes, and is allopatric, only occurring on the Pacific versant. Silverstoneia flotator has a white ventrolateral stripe, whereas P. lugubris lacks any such stripes on the ventrolateral region of the body.</SimilarSpecies>

<Calls>Males call from hidden locations throughout the day, but especially in the morning and afternoon, producing a long (often 10 seconds or more) musical trill, which is very similar to that of Phyllobates vittatus</Calls>

<RangeAndHabitat>Phyllobates lugubris is found in the lowlands and foothills of the Caribbean versant, ranging in elevation from near sea level to ~750m. This locally common diurnal species tends to prefer habitats associated with the banks of small streams and low lying areas.</RangeAndHabitat>

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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Phyllobates vittatus</SpeciesLatin>
<SpeciesEnglish>Golfo Dulce or Striped Poison Frog</SpeciesEnglish>
<Description>Phyllobates vittatus is a small to moderatesized (~25– 35mm, ~1– 1.4in), and robust frog. This species has smooth dark brown to black dorsal skin with a pair of light orange to reddish-orange dorsolateral stripes that extend from the tip of the snout to the sacrum. Some individuals may have some smaller orangish spots in the center of the dorsum. The ventral surface of the body and limbs is often dominantly covered in a light greenish-blue color. The throat is normally dark brown to black with some scattered, smaller whitish-blue to greenish-blue markings. The upper surfaces of the limbs are heavily pigmented by principally greenish-blue coloration, but some individuals may also have some light copper hues. The fingers and toes lack interdigital webbing.</Description>
<SimilarSpecies>Phyllobates vittatus is similar in general appearance to Allobates talamancae, but differs due to its cream to light brown dorsolateral stripes, and a solid white venter. Phyllobates lugubris is most similar, but typically has thinner dorsolateral stripes that range in color from dark yellow to yellowish white, and is allopatric, inhabiting the Caribbean versant.</SimilarSpecies>
<Calls>Males call from hidden locations throughout the day, but especially in the morning and afternoon, producing a long (often 10 seconds or more) musical trill, which is very similar to that of Phyllobates lugubris</Calls>
<RangeAndHabitat>Phyllobates vittatus is endemic to Costa Rica, only found in a small section of the lowlands and foothills of the southwestern Pacific, at sites ranging in elevation from near sea level to ~600m. This diurnal and locally common species often prefers habitats associated with the banks of small streams and low lying areas.</RangeAndHabitat>
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</FrogSpecies>

<FrogSpecies>
<SpeciesLatin>Silverstoneia flotator</SpeciesLatin>
<SpeciesEnglish>Rainforest or Floating Rocket Frog</SpeciesEnglish>
<Description>Silverstoneia flotator is a tiny (~15– 18mm, ~0.6– 0.7in), yet robust frog. This species has smooth brown to black skin dorsally, and a pair of white oblique stripes. The extent of the dorsolateral stripes varies between the Pacific and Caribbean populations. Pacific S. flotator have more complete white oblique stripes that extend from the groin to the upper eyelid, whereas Caribbean versant S. flotator have stripes that only extend from the groin about one fourth to one third the distance to the eye. From the tip of the snout to the groin there is a white ventrolateral stripe. The upper surfaces of the limbs are a light tannish-orange. The ventral surface of the body is white. Males have a light tannish-gray, subgular vocal sac, but lack nuptial pads. Finger III of adult males is noticeably wider and longer compared to the other fingers. The fingers and toes lack interdigital webbing.</Description>
<SimilarSpecies>Silverstoneia flotator might be confused with Allobates talamancae and Silverstoneia nubicola. Allobates talamancae can be distinguished from S. flotator due to its cream to light brown dorsolateral stripes, and a black throat in adult males. Silverstoneia nubicola most resembles S. flotator, but can be distinguished by its yellowish venter and black throat in adult males.</SimilarSpecies>
<Calls>Males call from among the leaf litter, or hidden sites on the ground and from low perches throughout the day, producing a series of quick high-pitched chirps</Calls>
<RangeAndHabitat>Silverstoneia flotator occurs on both the Caribbean and Pacific versants. The elevational range for S. flotator is from near sea level to ~900m. This common, diurnal species tends to prefer undisturbed forested habitats near shallow seepages and small streams.</RangeAndHabitat>

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</ArrayOfFrogSpecies>
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